Region

November 1988

Managing Competing and Unwanted Vegetation

Final Environmental Impact Statement

Appendices A, B, C, E, F, G, J, K

Appendix A

Timber Growth and Yield Analysis

A

Appendix A

What Reviewers Said

1. Explain differences in predicted timber yield effects between this EIS and those done by the Pacific Southwest Region of the Forest Service (Region 5) and the Bureau of Land Management (BLM) of Oregon.

2. The logic for extrapolation of growth and yield results to the Region--and the use of only full-yield suitable lands--needs clarification.

3. More detailed information is needed on assumptions and methodology used for growth and yield analysis.

4. Conduct a sensitivity analysis to establish some confidence limits or reliability of the long-term sustained timber yield estimates.

Our Response

1. We added a description of the coordination efforts among agencies and the different conclusions regarding timber yield predictions among Regions 5 and 6 and the BLM in Oregon. A summary of a coordination meeting among the agencies is included in the Timber Yield Effects section.

2. We clarified and redefined the process for extrapolation of timber yield results across the Region. We included our rationale for using only full yield suitable lands.

The extrapolation process is discussed in Chapter II, Technique Effectiveness section, in Chapter IV, Timber Yields section and in Appendix A, Subregional Effects on Timber Yields section.

The logic for using full yield suitable lands is in Appendix A, Stratification and Methodology section.

3. Material added to Appendix A provides a clear decision path to the conclusions. The addition discusses major assumptions, use of key studies, prescription details, and growth simulation results. We added two tables covering prescriptions and simulations.

4. We conducted a sensitivity analysis based on existing data to establish reliability of estimates. A summary of these findings is located in the back of Appendix A.

Appendix A

Timber Growth and Yield Analysis

Table of Contents

Introduction

There are about eight million acres (approximately one-third of all lands managed by the Pacific Northwest Region) that will be managed for "full timber yields" under the Forest land management plans. These lands are also expected to yield high quality water, provide habitat and forage, and retain their potential capacity for production of both these tangible commodities and not-so-tangible values, such as rare species and plant diversity.

Even with an intensive management strategy, it is unlikely that maximum yield (the full biological site potential) and the elimination of all competition will be achieved in the management of these public lands. While competing vegetation is often detrimental to conifer growth, in certain situations or growth stages it may be beneficial. These potential benefits, noted by Walstad and Kuch (1987), include:

1. prevention of soil erosion on disturbed or unstable sites through protective canopies or root systems;
2. nutrient uptake and storage, and recycling of nutrients that may otherwise be lost following harvest or other site disturbance;
3. improvement in soil physical and chemical properties through addition of organic matter and nutrients;
4. amelioration of excessively hot, dry, or cold (frost) conditions in new plantations due to shading or mulching;
5. protection of seedlings from browsing or grazing animals, such as deer, elk, and cattle; and
6. reduction or elimination of damage from conifer diseases (e.g., root rots) through effects on soil-borne pathogens.

A major problem is the lack of linkage between short-term observed effects (such as growth response from reduced competition; growth reduction associated with nitrogen loss; and reduction in growth associated with the reduction of mycorrhizal populations) and other long-term yield effects. Research in these areas is not available. Long-term studies and record keeping are critical needs.

Regeneration is an ongoing process in nature, particularly after a disturbance such as fire or timber harvest. The competition for newly available space is fierce. There are usually excess individuals competing for the site's limited resources. Competition is so intense that

usually many more individuals die than survive. Death soon after germination often results from lack of resistance to short-term climatic extremes. Thus, the total number of individuals sharply decreases, leaving the better adapted, more competitive plants. This process is well known as "survival of the fittest".

As individual plants grow, they require more space and resources, and natural thinning from direct competition results. There are numerous articles describing the effects of competition. White and Harper (1970) illustrate the "natural thinning curve" with farm crops, and Drew and Frewelling (1979) used 313 forest sites analyzing volume growth and tree density following the "-3/2 power law" which gives the general form for the reduction of individuals (density) with an increase in volume production. (See Fig. 1). This principle is the basis for response from vegetation management activities. In a resource-limited system (most are), as the numbers of individuals are reduced the remaining plants will access the released space and resources.

Although the complex, competitive interaction between and within species is not completely understood, the type and degree of response is known to depend on a number of site-specific variables. The species of crop tree, the species of the competition, their age, size, and vigor influence the amount of response. The intensity of competition by a species also depends on whether that species is near the optimum or limits of its environmental range. Variation in response associated with a species can be significant. With over 50 possible competitors and their varied responses, throughout the Region, much basic information is needed.

Water, nutrients, and light are most often the limiting resources. All affect growth and survival, but each has a different physiological effect. For example, height growth is achieved in a short period early in the growing season, but diameter growth can occur throughout. This means that early water shortages could affect both height and diameter growth, but later shortages may only affect diameter growth.

It is clear that a reduction in numbers of individuals or cover of the competition will result in a response from the crop tree. The general form of the response is shown in Figure 2, but the absolute values on both axes are dependent on site-specific conditions. These environmental variables and limiting factors must be carefully identified in the silvicultural diagnosis.

Assumptions and Qualifications

1. Cost-of-doing business and economic efficiency are not limitations.

The reality of budget levels and economic thresholds are addressed in Chapters III (Affected Environment) and IV (Environmental Consequences) of the EIS. This assumption is used to focus on environmental factors related to treatment effectiveness. Likewise, the relative safety risks of techniques will be disregarded in this analysis, but are addressed elsewhere in the document.

The decision not to apply uniform budgetary constraints to the alternatives is based on a sensitivity analysis documented in the section on Alternatives Considered but Eliminated from Detailed Study (Chapter II). The estimated change in annual budget for alternative implementation is shown in the Cost/Benefit section of Chapter II.

A conclusion based on feedback from the nineteen National Forests was that the overall purpose and theme of the alternatives had more influence than either the budget or output emphases. Regionwide, it would take only a moderate increase in program budget to implement alternatives other than B—the baseline alternative. The costs of activities will vary, but will not exceed budgets which can be reasonably expected. The size and importance of the plantation maintenance program in the Pacific Northwest Region would indicate that modest increases in operating budgets would be acceptable in order to implement the selected alternative. Appendix E (Silviculture Program Effects) highlights the differences in treatment costs by various methods and techniques.

2. Broadcast burning is assumed to be available if considered appropriate for meeting site preparation objectives.

In other words, this analysis does not address a concurrent loss of both herbicides and controlled burning in the vegetation management program. An analysis of the role of burning in the reforestation program is made in Chapter IV (Environmental Consequences).

3. Substitutability—the ability to replace one method with another—is generally assumed in this analysis.

Limitations on substitutability are major operational considerations in the silvicultural program and are an important component of assessing consequences. Appendix E describes the logistics, administrative factors, and limitations for substitution of techniques. This information is used as background for this analysis.

Restrictions on management options can be caused by factors such as terrain limitations, availability of vendors or equipment, and other operational constraints. These operational restrictions are factored into this analysis at several points. Examples in this appendix are found on pages:

A-20: 20 to 30 percent of plantations in the east side pine/grass community will require a release treatment to control herbaceous vegetation, in addition to site preparation, to maintain acceptable stocking and early growth.

A-21: An operational release program in the pine/shrub/herbaceous complex using manual, mechanical, and biological methods (no herbicide use) could accommodate approximately two-thirds of the grass control needed to release intensively managed pine plantations.

A-24: 15 to 20 percent of the reforestation efforts in the extensive Ceanothus species complex will require treatment of older or well established brushfields.

Occasionally, a failed plantation will result in the need for replanting (or interplanting), in a situation with a more severe degree of site competition. Also, the need for reforestation of sites severely impacted by wildfire can create scheduling and logistical factors. Two examples of these problems include inability to procure seedlings, or the inability to complete site preparation (by burning) within the seasonal "window" for such activities.

A-30: Successful regeneration is considered impossible without herbicide use on 50,000 acres of tanoak-dominated sites in southwestern Oregon. These are stands of nearly pure tanoak planned for conversion to conifer plantations, and stands of existing, poorly-stocked conifers with a large pre-existing tanoak component. These situations represent an especially severe degree of competition, and comprise about 30 percent of the total Douglas-fir/tanoak-madrone/herbaceous complex.

A-33: Loss of herbicide use will significantly reduce treatment effectiveness on an estimated 10 to 15 percent of acres within the true fir-hemlock/shrub/herbaceous complex. These are sites dominated by extensive sod-forming grasses and weed species on which whole area mechanical or manual scalping is operationally infeasible.

This condition is centered in the southern Cascades and higher elevations of eastern Oregon. Poorly developed soils (having nutrient

capital concentrated in surface horizons) complicate the situation. Another complication can be the need to control pocket gopher habitat.

The assumptions dealing with substitution and operational constraints were reviewed by eight experienced Forest or Regional Office silviculturists in order to develop some element of consensus regarding the magnitude of the particular problems. It must be noted that "substitutable" does not necessarily mean that methods are always "interchangeable" in terms of efficacy of treatment.

This analysis is an effort to identify specific situations in which early tree survival and growth will vary according to treatment method. In other words, the assumption is made that in certain combinations of vegetation, precipitation patterns and operational environments, there are some intrinsic differences among the tools used for vegetation management. Forests will likely go to great efforts in order to implement the final EIS decision and chosen alternative (for example, under Alternative A, to identify site-specific conditions where manual release can be substituted for chemical use while continuing to meet prescription objectives). Assumptions regarding method substitution have, therefore, been pushed to the limits of operational feasibility in order to reflect the most likely strategy used in the implementation of a final EIS.

4. A generic strategy will be assumed for this analysis: even-aged management using artificial regeneration, intermediate thinnings where appropriate, and final harvest at the physical rotation age (95 percent of culmination of mean annual increment of growth measured in cubic volume).

This is done for ease of modeling timber yields over time, and to reflect a sequence of events often used on intensively managed timberlands in the Pacific Northwest Region. In actual practice, the selection of silvicultural systems for site-specific prescriptions are based on management objectives, limitations within the operational environment, vegetative response, and guidelines provided in Forest Land Management Plans and the Regional Guide for the Pacific Northwest Region.

This assumption forces an extreme simplification of the diverse harvest systems, environmental conditions, and silvicultural strategies now being employed in the Pacific Northwest Region. Rotation length is a key variable in the estimation of timber yield effects. Short rotations, for example, will magnify the relative effects of early growth suppression in managed stands. Those used in this assessment will be

the most representative management regimes for the Forest planning "full yield" timberland component of each specific combination of vegetation being analyzed.

Roughly 30 percent of the suitable timberland base has been programmed for less than the full managed yields by the land allocation decisions made in the individual Forest land management plans. This is done to accommodate important resource uses or values, such as specific wildlife habitat requirements, visual quality objectives, or potential for soil damage leading to reduced long-term productivity.

In practice, harvest prescriptions on these lands may involve extended rotations to produce a desired tree size, reduced frequency of cutting, multi-aged management to maintain a continuous high-forest appearance, smaller-than-normal cutting units, or efforts to create a specific species composition or vertical distribution of canopy levels. This management scheme represents a relatively common difference in management objectives between Forest Service and industrial forest ownerships.

5. Vegetation control is assumed to be geared primarily toward conifer seedling establishment and growth. In reality, these activities often have dual-purpose objectives.

Examples are controlled livestock grazing in established plantations to improve forage utilization as well as conifer release; burning for reduction of fuel accumulations and creation of favorable seedling microsites; or grass-sedge control in high elevation units in order to limit pocket gopher populations and subsequent tree damage.

6. Timely reforestation treatments following site disturbance (timber harvest or wildfire) has been assumed.

This means that the status of conifer seedlings is initially approximately codominant or better with associated vegetation. Reforesting while brush-grass-herbaceous invasion or development is still at manageable levels improves the probability of successfully meeting prescription objectives, and also keeps treatment options open.

Lands programmed for full timber yields will rarely sit fallow for long periods. There will be times when delays are unavoidable and older brushfields or well-established competing vegetation must be controlled during site preparation and early stand maintenance. This can be the result of our large scale of operations; a need for replanting or interplanting failed units; fire rehabilitation; or logistical problems such as getting the correct seedlings or the inability to finish all planned burning for site preparation within the seasonal "window". In

these situations, the degree of competition among conifer seedlings will be more severe than normal. These factors are incorporated into the assessment for the three most extensive vegetation complexes—the ceanothus species; eastside pine-herbaceous; and true fir-hemlock complexes.

The sheer size of the land base under management—and a budget-planning process that involves speculation over a several-year period—will occasionally result in an unacceptable time lag before treatment. A typical operational problem is the coordination of nursery sowing schedules with anticipated future logging priorities.

Several variables in the sequence of events needed to successfully reforest a site will influence the need for conifer release. These may include things such as seed availability, seedling quality, planting quality, or the success of a prescribed site preparation broadcast burning. Most of the available literature dealing with the effects of competition reflects studies conducted on sites where some disturbance of pre-existing vegetation has occurred. For this reason, the yield effects which would occur under Alternative C (no vegetation management) will be somewhat greater than those reflected in this assessment.

7. A moderate level of damage to crop trees during vegetation management is anticipated and considered acceptable in operational projects.

Elements such as scattered foliar or leader damage during herbicide application, seedling trampling or browsing by livestock, or physical crushing or deformity caused by manually treating brush can occasionally be a severe site-specific impact.

Examples of unacceptable herbicide damage are documented by both Newton (1978), and by Gratkowski and Lauterbach (1974); while heavy damage during manual cutting is seen in Hobbs and Wearstler (1985) and Roberts (1980). In the great majority of treatments, however, crop tree damage is either transient in nature, or the tree loss not severe enough to cause a falldown in volume yields in the merchantable stands. Many of the studies being used in this analysis, in fact, record an inconsistent height-increment response following treatment. This is partly a reflection of this individual crop tree damage during treatment. On a programmatic basis, a practice that consistently results in high levels of tree loss or deformity will simply be discontinued or modified to correct the problem.

8. The presence or absence of significant competition for conifer seedlings is directly related to the extent and volume of associated vegetation.

Managed yield tables developed for Forest plans are an expression of conifer growth potential under a light-to-moderate degree of inter-species competition in newly established stands. Total elimination of associated vegetation is rarely the objective during plantation establishment and maintenance. This is a reflection of the trade-offs between the beneficial and negative aspects of woody shrubs and herbaceous vegetation. It also reflects the fact that total vegetation control is neither silviculturally feasible nor necessary for attainment of management objectives.

Managed yield tables prepared during the Forest land management planning process represent survival and growth objectives associated with vegetation management treatments. Yield projections and process records are available at the headquarters of each of the nineteen National Forests.

These yield objectives are optimized from the standpoint of multiple-use management. They do not, however, represent the maximum achievable for a given site under total vegetation control, or the so-called "bare-ground" style of management. In other words, timber yield projections under the "full-yield" component of the suitable timberland base have already incorporated a volume reduction in order to accommodate a low to moderate amount of competition from competing vegetation.

A competition threshold level effect has been displayed in work by Oliver (1985) and others. An effort has been made to select studies used for growth comparisons which reflect a severity or degree of competition similar to that commonly found in operational prescriptions. These studies are weighted heavily in the prediction of tree mortality, form defects, or tree height and diameter growth effects. This forces an extreme oversimplification of some complex and varied site-specific situations, but is necessary in order to model a cross-section of the common site conditions encountered.

It is difficult, if not impossible, to extrapolate from highly site-specific growth effects to broad scale generalizations. Controlled experiments produce specific results that may not be representative of those occurring in a more heterogeneous forest environment. For this reason, there is an inherent danger of exaggerating broad-scale timber yield effects based on controlled research. A degree of caution and conservatism is, therefore, incorporated into this analysis. Results from

long-term monitoring studies eventually will provide answers to questions being addressed in this EIS.

An analysis of this sort involves limitations:

1. There is a growing body of data and sources of information related to the effects of competing vegetation. All published information pertinent to Oregon and Washington, however, documents only a short time frame during the stand management cycle. This means that translation of early growth and yield effects into managed stand yields (over rotations that are typically 80 to 120 years) involves much extrapolation and uncertainty. There is also a general shortage of empirical information regarding long-term effects of vegetation management on the site productivity of western United States forest lands.

This lack of long-term stand monitoring presents a problem in displaying the reduction of tree growth and vigor which may linger in unreleased trees that grow through competition.

A comparatively long-term study (28 years) reported in Strothmann and Roy (1984) indicates that tree vigor differences (expressed as needle complement, needle length, and needle color) continue to be apparent in released and unreleased trees. Most data used in this analysis covers a period of less than ten years.

To account for this "memory" of growth suppression and loss of vigor (due to reduced crown or root system development, form defect, rooting depth, etc.), the short-term height and diameter increment trends will be projected to age 15 to 20 years (see Attachments 1 through 7). At this point, the unreleased conifer is assumed to have established sufficient dominance over competing vegetation to grow at rates comparable to a tree which has been "free-to-grow" throughout its life. In other words, the growth curve is simply interrupted for the first one-and-one-half decades. There is, however, some evidence that understory brush can cause serious growth suppression in older sapling and poletimber stands (Oliver, 1984, and Barrett, 1982).

Attachments 1 through 7 are simply linear projections of some short-term growth trends drawn from research. This is done in order to acknowledge the lingering effect of interspecific competition while these hypothetical stands are "grown" to a common age for use in growth simulations.

Much of the literature indicates that exponential functions of growth trends are most appropriate (Preest, 1977, Allan et al., 1978, Ross et al., 1986, and Harrington et al. 1983), and that linear extrapola-

tions may underestimate the effects of early vegetation management. The purpose of this analysis is to display relative differences between management prescriptions (alternatives), rather than to calculate rotation length yields to a high degree of precision. For this reason, the subjective linear projections are felt to be acceptable.

During the second decade of stand development, intraspecific competition may become more significant than interspecific effects. On full-yield or intensively managed sites, however, stocking control and density management principles are generally employed during young stand tending.

2. The literature dealing with the effects of competing vegetation on conifer growth is occasionally erratic or conflicting in terms of conclusions drawn. An effort was made to review the available information. The experience and opinions of USDA Forest Service field practitioners and other special lists were used in those cases where the literature is inconclusive. (Process records identify the individuals and organizations consulted during the analysis.) For consistency with the NEPA implementing regulations, only published information and data (or that on file and reasonably available to interested parties) will be utilized.

3. Potential yield effects due to seedling or sapling mortality are measured against the stocking levels used to certify plantations as successful. These are tree numbers which provide the commercial thinning yields anticipated in many of the managed stand projections used in Forest plan development.

Acceptable stocking levels vary by combinations of timber type and site quality. During diagnosis and prescription, silviculturists attempt to predict some tree mortality based on experience and past survival in similar plantations. A certain degree of seedling loss prior to plantation certification (normally after a third or fifth year examination) is considered acceptable. For example, if initial planting is done at 400 trees per acre and acceptable stocking is 300 trees per acre, the stand can absorb a 25 percent loss and still be successful in terms of meeting management objectives. Attachment 12 presents the detail for prescriptions used in yield comparisons. Anticipated tree stocking levels at a stand age of 15-18 years for the full-yield prescriptions are:

Table A-1

Vegetation Complex	Trees per Acre
Douglas-fir/alder	260
Douglas-fir-hemlock/salmonberry/herbaceous	300
Ponderosa pine/grasses-herbaceous	200
Douglas-fir-ponderosa pine/Ceanothus spp./herbaceous	300
Douglas-fir/tanoak-madrone	300
True fir-hemlock/shrub/herbaceous	350

4. This assessment is made within limitations of time and data availability, and is intended as an estimate of consequences within NEPA guidelines. Several long-term comprehensive studies are currently underway which will help identify treatment alternatives, growth and yield effects, and cost factors. The high priority nature of these efforts and the need for carefully designed study protocol are illustrated in Owston et al. (1986).

Examples are an effort begun in 1980 in northern California through the Pacific Southwest Forest and Range Experiment Station, the Pacific Northwest Station's Treatment Monitoring Study, and a study in southwestern Oregon started in 1983 through the Forest Intensified Research (FIR) Program of Oregon State University.

Some individual Forests are also conducting administrative reviews or studies to monitor and use vegetative growth effects information. An example is a Siskiyou National Forest interpretation of on-Forest monitoring plots. These results will not be available for this EIS. However, as more precise or reliable information such as this becomes available, it will be utilized in project planning and implementation at the Forest level.

5. There is uncertainty involved in extrapolation from site-specific results to general observations, based on a limited number of studies. This uncertainty is then compounded with the expansion by acreage estimates. For this reason, the timber yield effect estimates for each vegetation complex will involve some large statistical error terms. These estimates, however, are adequate for a display of the magnitude of change between alternatives in the EIS. It should be emphasized, however, that these estimates simply represent the approximate mean of a range of results.

Sensitivity analysis has, therefore, been used in an effort to define (to a degree) the reliability or accuracy of the projections. Attachment 13 gives a description of prescription, site, and model variations used to test yield effects shown in this analysis. (These are process records available at Forest Pest Management, Pacific Northwest Region, Portland, Oregon).

In addition, an analysis was made to gauge the degree of dependence shown in the economic effects analysis to changes in allowable sale quantities (ASQ's). This analysis and economic criteria responses are summarized in Appendix B (pages B-27 to 29).

Yield Reductions

Managed yield tables developed for Forest Land Management Plans represent the optimum timber yields from lands suitable for intensive management. There are four situations which can result in reduced yields over time:

A. The first situation is a delay in early stand development (due to vegetation competition) that results in an extended rotation length. This may be due to a prolonged culmination of growth, or a delay in reaching a desired product size. We can achieve the same stand yields; it simply takes longer to occur in the absence of vegetation management. This extended rotation is the most significant impact in terms of potential harvest level reductions.

B. The second situation is tree mortality, vigor or form defects, and the suppression of growth which results in dead or submerchantable trees within the managed stand. This will translate into reduced commercial thinning opportunities and understocked areas within the stand. The disruption of normal stand development can also result in increased heterogeneity in terms of product size and species composition.

C. The third situation occurs where restrictions on vegetation management options can lead to changes in the timberlands' suitability classification made during the Forest planning process. Specifically, these are situations where the absence of vegetation management creates a high risk of regeneration failure. For example, this may relate to vegetation composition and structure, or physiographic conditions that produce a high risk regeneration effort in the absence of a specific management technique. The net effect on site productivity will be estimated for these conditions.

In other words, any reclassification of lands suitable for intensive timber management will be made in the Forest land management plans rather than this EIS. If the alternative selected in the Record of Decision would materially limit the ability of National Forests to meet timber outputs on some suitable lands, adjustments will be considered on a case-by-case basis within the context of an approved land management plan.

D. The final situation is a shift in species composition in response to early vegetative competition in mixed species stands. For example, relatively shade-tolerant species may gain dominance within the stand in the absence of vegetation control. Factors such as growth patterns, susceptibility to physical damage or pathogens, and reduced product values then become important. Another element of this shift in species composition can be a relative increase in hardwoods which typically have limited commercial value in the near future.

Stratification and Methodology

Six vegetative complexes will be examined in order to present a cross-section of conditions in the Region and to take advantage of the most pertinent available literature. These vegetative strata represent 55 percent of intensively managed "suitable" timberlands in the Region. The extent and geographic distribution of these strata give a cross-section of lands for the display of relative changes between alternatives in the area of timber growth and yield:

A. Douglas-fir/alder

B. Douglas-fir-hemlock/salmonberry/herbaceous

C. Ponderosa pine/grasses-herbaceous

D. Douglas-fir-ponderosa pine/Ceanothus spp./herbaceous

E. Douglas-fir/tanoak-madrone

F. True fir-hemlock/shrub/herbaceous

These vegetation types provide a simple characterization of some common site conditions and provide an opportunity to utilize most of the available data sets dealing with effects of competition on conifers. This type of stratification, however, obviously oversimplifies some extremely variable situations. Common shrub components and other associated species will be identified for each vegetation complex. The grass and weed herbaceous component will also be addressed within

most of the individual complexes. An advantage of this particular stratification scheme is the fact that it accounts for an estimated 90-plus percent of the historic use of herbicides (on sites where the technique was selected mainly for reasons of effectiveness rather than for treatment cost considerations).

Process steps and methodology:

Several methods have been used to estimate the effects of competing vegetation on timber stand development. The approach used here is similar to what Walsted and Kuch (1987) call a "simulated managed stand comparison method". The example used in Walstad and Kuch (1987) projects stand structure and development for sites which were initially similar, but which received different vegetation management treatments.

The simulated managed stand comparison method requires a stand simulator that will accept differing density and tree size information for comparisons of the "treated" and "not treated" conditions. Another requirement of this approach is a need for relatively "long-term" records of vegetation management treatments. In this analysis, hypothetical stands will be developed from some representative reforestation prescriptions. The stands will then be standardized in time (at age 15 to 20 years) using projections of growth and survival trends taken from the literature.

Step 1. Identify growth and yield effects related to competing vegetation in each vegetative complex. This will establish a short-term relationship between a fully managed (or so-called "free-to-grow") condition and the "little-or-no" vegetation management situation normally reflected by test controls. One or several data sets will be selected as representative, and the height and diameter increment trends projected to age 15 to 20 years. Seedling mortality, in the absence of vegetation control, will also be estimated. Related factors such as trade-offs, competition threshold levels, and environmental factors affecting treatment effectiveness will also be examined where appropriate.

A basic reference on the subject is Effects of Competing Vegetation on Forest Trees: A Bibliography with Abstracts, USDA-FS, Gen. Tech. Rpt. WO-43, Sept. 1984. This is supplemented by subsequent publications, symposium and workshop proceedings, research progress reports, and other materials.

Step 2. The short-term growth estimates will be projected in yield simulations for comparable yield effects. This will display the per-acre

yield difference between the operational site potential and the "little or no vegetation management" situation.

Copies of yield simulations are process records on file (USDA Forest Service, Forest Pest Management, Portland, Oregon). Attachment 12 summarizes information on prescriptions, input variables, and important output variables from model comparisons.

Long-term (rotation length) yields from the growth models should be a reasonable approximation of output levels under an unconstrained management regime. In other words, they serve as a proxy for the managed yield projections under Alternative B. The "little or no management" comparison will then show a proportionate change in yields over the course of a typical rotation.

Step 3. Expand the per-acre effect by an estimated total area for the display of the magnitude of volume reductions related to the lack of vegetation management.

The yield effect will be extrapolated directly to the full yield component of the vegetation complexes.

(Steps 4 and 5 are an effort to address the relative effectiveness of herbicide use and alternative techniques under specific vegetative and physiographic conditions.)

Few studies have been designed for a direct comparison of treatment effectiveness between vegetation management techniques. As a general statement, the biometrical data base is weak for mechanical, manual, and biological (including grazing) methods in comparison with that available on herbicide use.

Step 4. Identify vegetative conditions or operational factors which show efficacy differences between herbicide use and other available tools—manual, biological, thermal, and mechanical. In other words, there are specific situations where differences in treatment effectiveness can be shown, and for which the solution is not to simply spend more money.

Step 5. If applicable, expand Item 4 by total affected area to display a magnitude of yield effect related to the suspension of herbicide use.

Yield model comparisons will be made with simulations appropriate to the geographic province. This will be either Stand Prognosis (Wykoff et al. 1982), the DFSIM model (Curtis et al. 1981), or Stand Projection System (Arney 1986).

Rotation lengths and management schemes representative of those used in Forest plans will be used in model comparisons. Modal site qualities for each vegetative complex will be used. On high quality sites, the percentage yield loss will be less than on low sites, although absolute volume effects may be greater (Fiske 1984). Site indices from the studies selected to display short-term growth trends will be held constant for modeling of long-term yields.

Stand projection models (such as DFSIM and Stand Projection System) assume a mean tree response. An individual tree growth model, such as Prognosis, incorporates a feature which will provide a more realistic projection of stand development in terms of tree diameter distribution. Recent evidence from Peterson (1988) suggests that the presence or absence of vegetation management can result in substantial differences in the distribution of tree sizes within a stand. Unfortunately, the final stand yields (and also product values) can be linked to these differences in diameter distribution. The differences could not be calculated for five of the six vegetation complexes (analyzed with models other than Prognosis), but should be recognized as a limitation to the analysis.

It must be emphasized that only areas to be intensively managed (timber yields approaching the full biological site potential) are involved in the analysis. Affected areas will be estimates because of the very simplified vegetation combinations being used. (Process records are on file.) On those lands where reduced timber yields are anticipated (to accommodate other resource values or management concerns), it is difficult to correlate the vegetation management growth effects with actual timber harvest levels.

This means that approximately 30 percent of the suitable timberland base in the reduced or partial yield component will not be addressed in this analysis. In reality, this is only a minor factor. For all Forests, the first decade harvest schedule developed through FORPLAN modeling in their Forest Planning Process projects 90-plus percent of timber yields coming from the full-yield land base. Timber harvest prescriptions on partial yield acres are made in order to accommodate a variety of management objectives, with timber yields often being only a byproduct during the achievement of these objectives. This typically means that programmed timber yields are proportionately small in comparison to the number of acres being treated. In other words, 30 percent of the suitable land base will generally contribute less than 5 percent of the programmed volume harvested for the near future.

The bridge between short-term growth effects and rotation-length timber yields is weak because of growth model limitations, the need to generalize from site-specific data, and compounded error terms. However, these long-term estimates will provide an approximation of differences in timber yields between Alternatives A, B, and C. It must be emphasized once again that error terms for yield effects, particularly those associated with an absence of herbicide use, cannot be clearly established due to the variability in study criteria, statistical parameters, time frames, severity of competition, etc. There is no intent to imply a high degree of precision, but only to characterize some relative differences between alternatives in a NEPA document. Sensitivity testing of the model is discussed in Attachment 13. This was an effort to define a level of reliability in the number estimates.

Douglas-fir/alder Analysis

Step 1 Information Review

The humid climate within the normal alder range would indicate that light is relatively more limiting than soil moisture in this complex. This also means more options are available in the management of competing vegetation and a larger "margin of error" in comparison with more drought-prone situations. Chan and Walstad (1987) find a consistent correlation with "percentage of sky visible" and second-year basal diameters and tree volumes on three Oregon Coast Range sites.

Red alder is moderately intolerant of shade but will survive in an understory for several years. Full sunlight, however, is needed for normal development. Alder regeneration is commonly by natural seeding, although vigorous stump sprouting may follow site disturbance (DeBell and Turpin, 1983). If uncontrolled, the rapid juvenile growth of alder can establish tree position dominance over conifers for 25 years in mixed stands (Miller and Murray, 1970). Measurements in this study show dominant Douglas-fir emerging from the alder canopy at age 30 years.

Conifer stocking losses due to prolonged suppression are difficult to estimate, particularly in mixed stands where trees are initially in a codominant position. Walstad et al. (1986) analyzed stands established in the 1950s and 1960s in which growth and species composition records could be reconstructed. Two untreated sites, converted essentially to alder, had total yields (at age 60 years) that ranged from 46 to 62 percent of those in adjacent treated (released) stands. Product values on the untreated stands, however, were only 7 percent and 11 percent (respectively) of those for treated (pure Douglas-fir) stands.

Projections for stands from a third location showed the untreated stand yielding 87 percent of the treated at year 60.

Tree vigor differences after five years between released and unreleased trees are reported by Lauterbach (1967). In this case, suppressed Douglas-fir growing beneath alder are spindly, short, sparse-needled, and yellowish-green in color. Tree mortality and occurrence of submerchantable conifer in mixed stands appears to be a factor primarily in severely suppressed conditions, or a lengthy delay in conifer seedling establishment. This threshold level for seedling loss is observed by Lauterbach (1967).

Cole and Newton (1986) evaluated nutrient, moisture, and light relations in Douglas-fir plantations under variable competition—either from grasses or red alder. Competition due to grass was primarily for moisture, with stresses greater on drier sites (valley and midrange) compared to Coastal sites. Red alder was found to compete for both moisture and light.

Plantation failures (i.e., when seedling survival falls below minimum acceptable standards) are rare within the alder belt. During 1986 and 1987, for example, over 20,000 acres were planted on the Olympic and Siuslaw National Forests. Total replanting for these years on these Forests was only 61 and 26 acres, respectively, or less than 1 percent of the total reforestation acres shown on the annual Silvicultural Accomplishment Reports. During 1987 surveys (Plantation Survival and Growth, and Nursery Performance Report) satisfactory third-year stocking was shown at 98 and 99 percent of plantation acres for the Olympic and Siuslaw Forests, respectively.

Diameter growth appears to be strongly responsive to competition. Several authors have shown that early suppression of diameter growth will increase the ratio of height to diameter. Harrington and Wagner (1986) indicate that the height:diameter ratio can be used as a reliable competition index and predictor of decreased future growth. As a general statement, diameter increment is a more reliable indicator of suppression in stands less than ten years old than is height growth.

Stein (1984) shows survival differences at year five in a comparison of several site preparation treatments. Lowest survival (54.3 to 64.7 percent) is reported on areas where competing vegetation was advanced at planting time. There were only minor differences in a comparison of fifth-year survival on three prepared sites (70.0 to 76.2 percent) to an untreated control (64.1 percent) in the Stein study. Tree mortality does not appear to be an important concern when reforestation is timely following site disturbance on alder influence sites.

Growth effects, however, can be severe. Allen et al. (1978) reports a 15 percent height growth increase and 74 percent increase in stemwood volume six years after release of Douglas-fir seedlings on a northern Cascades site. Lauterbach (1967) shows a height growth response (after six years) of 6 to 178 percent over an untreated control, depending on initial seedling height. Howard and Newton (1984) show overtopped seedlings to be smaller and to grow more slowly than those shaded by competing vegetation. In this study, growth reductions due to tree-form hardwoods—alder, maple, dogwood—were greater than those associated with encroaching lesser vegetation over the first several years of plantation development.

The beneficial effects of nitrogen enhancement in alder stands can also be a management consideration. There is much disagreement, however, regarding the trade-offs between alder competition and increased nitrogen availability. Nitrogen accretion is particularly significant during the first six years of alder stand development (Bormann, 1977). On infertile or nitrogen-deficient sites, the trade-offs between early conifer growth suppression and soil fertility are noted in Binkley (1984). Binkley et al. (1981) examined growth and nutrition of crop trees, with and without alder, in several 22-year-old plantations. In the study, the presence of alder did not significantly affect conifer stocking levels, basal area, and average diameter and height. The conclusion was that Douglas-fir yields, when stand canopies become similar, would be greater on the alder sites because of improved tree vigor.

A similar relationship is shown in work by Miller and Murray (1970). At age 48, Douglas-fir volume in a mixed stand was 3,100 cubic feet per acre compared with 2,900 cubic feet in a pure conifer stand. Miller and Murray (1970) suggest retention of 20 to 40 red alder per acre for enhanced Douglas-fir growth on sites where nitrogen may be limiting. The Siuslaw National Forest often carries this number of alder stems in regenerated Douglas-fir stands. One possible way to take advantage of nitrogen enhancement is the introduction of alder plants after conifers are established and stocking levels are controlled, but also while site resources are still adequate for nitrogen fixation (Helgerson, et al. 1984).

Nitrogen enrichment was not a factor, however, in several other studies. Cole and Newton (1986) observed no nitrogen accretion on moderately low nitrogen level sites after five years. Newton et al. (1968) observed accretion only under severe soil removal conditions. The conclusion, in a report of fifth-year results by Cole et al. (1983), is that alder growth habits appear incompatible with those of Douglas-fir

in the long run, and an association of species will lead to dominance by alder and negative growth impacts.

Nitrogen enhancement, when desired, can be the result of biological fixation or through use of inorganic nitrogen fertilizers. Each of these management options have advantages and disadvantages, as noted by Carlyle (1986). The use of manipulated plant associations for nutrient cycling, rather than direct fertilization, has a strong potential. However, as noted in Carlyle (1986), further research and development of new technologies may be required if the practice is to work consistently as a site-specific prescription.

Mixed stands of red alder and other species are more common than pure stands in most of the species range. The potential commercial value of alder is another beneficial aspect of an alder component. The low per-acre yields, high logging costs, and inconsistent markets have made alder values appear to be submarginal. There is growing interest, however, in hardwood markets for specialty and roundwood products.

Step 2 Yield Estimates

A growth comparison used to display yield effects in an absence of vegetation management is already available. The Siuslaw National Forest (Turpin et al. 1980) compares yields (mean annual increment, or M.A.I.) under a number of management alternatives, species combinations, stocking levels, and aspects in a decision tree analysis. Records from 324 plantations were used, with yield comparisons made with the DFIT Program, an earlier version of DFSIM. Average site index for the Forest is 170 (base year 100) and a rotation of 75 years was used. A conifer strata was identified (i.e., 90-plus percent of the tree crown area prior to harvest was coniferous.

Hardwoods were predominantly red alder, with some bigleaf maple. Three stocking levels were identified, with the Full Stocking strata (over 260 trees per acre) being most representative of a "full yield" management scheme. The No Vegetation Management Alternative in the study represents a "plant and walk away" situation. Results of the analysis show a 29 percent yield reduction for "no management" of the stocked conifer strata, in comparison with an "all tools available" alternative. A typical rotation, with thinnings, on intensively managed sites is 80 to 90 years in the current Forest Plan. This slightly prolonged growth period, in comparison to the Siuslaw Study, will tend to reduce the relative effect of the early growth suppression. Therefore, the estimated yield falldown is adjusted to 25 percent. (75 yr. divided by 85 yr., times 29 percent = 25 percent.)

Stands examined in the Walstad, et al. (1986) study appear to

represent the typical consequence of no or inadequate site preparation, and severe alder competition. In this case, the stands had converted to red alder by age 50 years, with commercial yields ranging from 46 to 62 percent in comparison to adjacent treated (released) sites.

The range of 25 to 50 percent yield falldown appears to represent a realistic range of what could be expected with no vegetation management on mixed species sites.

Step 3 Area Expansion

There are approximately 236,800 acres of this complex allocated to full-yield management in the Region. A predicted reduction in long-term sustained yield levels of at least 25 percent is presumed for this land base.

Step 4 Herbicide Efficacy

Herbicides have a long history of use for control of alder and associated species. Manual release cutting of alder, however, has been developed and refined for improved effectiveness and duration of control. An example is the Red Alder Severing Windows Study being conducted by Washington State Department of Natural Resources (Belz 1987). In many cases, the cost-of-doing-business is now the principal differentiation. Timelines of treatment, density of alder, and the need for adequate site preparation are factors which can limit the effectiveness of any chosen technique.

Stein (1984) compared several site preparation techniques, as well as stock types, in a post-logging reforestation effort. Fifth-year survival was similar on both sprayed and burned units—85.6 percent versus 86.2 percent. Total height of protected trees (plastic mesh in this case) was also relatively insensitive to method. A 1984 decision analysis (Knapp 1984) examined 324 plantations on the Siuslaw National Forest for the comparison of methods for control of competing vegetation. Manual control and phenoxy herbicide use were compared in various combinations of prelogging vegetation and aspect. In all strata examined, a restriction on phenoxy herbicides had minor effects on growth (MAI). The authors, however, emphasize that the study is specifically for the Siuslaw National Forest, and that the results may not be applicable elsewhere.

The Olympic National Forest has a large (111,000 acres) area of alder influence sites being managed intensively. The Olympic has relied primarily on manual treatments for alder control in the silvicultural program. A similar pattern has been shown in the conifer-alder component on Forests in the northern Cascades province.

Step 5 Herbicide Yield Effects

Based on information shown, plus assumptions used in this assessment (i.e., timely action following site disturbance and the disregard of treatment costs), the yield effects, due to method effectiveness differences, appear to be minor.

Turpin (1987) identified sources of new information and methodology which has helped the Siuslaw National Forest deal with an absence of herbicide use since a 1983 U.S. District Court of Oregon injunction against their use. These factors are:

a. The development of higher quality seedlings and animal control techniques with an effect of giving plantations a fast start and reducing the necessity for replanting.

b. Target stocking levels have been reduced as a result of better yield and economic models. The desired stocking at year ten is now 250 to 300 trees per acre, rather than the previous 430 trees per acre.

c. Forest-specific research to develop "windows of success" for hand release of red alder. Following the developed guidelines has given the Forest a success rate of 96 percent for hand release.

d. Treatment needs in a manual release effort can be confined to only that fraction of an area actually in need of release. Aerial herbicide application is by nature a more broad-scale operation.

Douglas-fir-hemlock/salmonberry/ herbaceous Analysis

Step 1 Information Review

Salmonberry and its associates (vine maple, thimbleberry, elderberry, alder, salal, etc.) have the ability to aggressively reoccupy a site following disturbance. Salmonberry and a number of other sprouting shrubs interact with an herbaceous weed and grass component. Wagner and Radosevich (1987) report that brush encroachment exceeded pretreatment levels within 2 years after manual cutting on salmonberry-dominated sites of the Coast Range. In second-year measurements, Roberts (1980) found treated areas recovered to 85 percent of pretreatment levels following manual cutting.

Chan and Walstad (1987) establish the relationship between available light and Douglas-fir sapling growth on some Coastal Oregon sites. Basal diameters and tree volumes show a strong positive correlation to light availability (percent of visible sky). Trees that were slightly overtopped may have also been affected by competition for

soil moisture, although to a lesser degree. Authors imply that, even in the moist Coast Range, the competition for available soil water may influence conifer performance.

Moderate to heavy volumes of this brush complex can cause competition for moisture and light for overtopped seedlings. A species composition index is being developed for the Siuslaw National Forest (Wagner and Radosevich 1987). When found in abundance, salmonberry and several other shrubs with rapid early growth (such as thimbleberry, vine maple, and hazel) were considered important during the first several years of plantation development. Later, they decrease in importance as Douglas-fir surpasses them in height.

Early planting of a prepared site appears to be particularly important when dealing with salmonberry and associated species. Newton and White (1983) found significant differences in seventh-year survival for all stock types planted initially in 0- or 4-year-old brush. Survival of released seedlings was 75 percent, compared to 38 percent for the unreleased trees initially planted in four-year-old salmonberry. In this case, mortality also added substantially to the number of years expected before stand crown closure. Stein (1984) shows slight improvements in fifth-year survival in a comparison of several release treatments. However, in two other studies by Stein (1986), and in previous work by Ruth (1956), there are no significant correlations between vegetation control and early seedling mortality. Third-year results showing Douglas-fir growth and survival following release treatments (on salmonberry-dominated sites) are reported by Harrington and Wagner (1986). The study sites were prepared (burned or sprayed) and released two to three years after planting (chemical or manual treatments). Douglas-fir survival was not significantly different among treatments after three years, including both the complete removal site and an untreated control.

Seedling survival on salmonberry influence sites appears to be directly related to adequacy of site preparation and timely reforestation. Tree mortality is consistently minor when conifers are established in a competitive crown position with the shrubs. The Newton and White (1983) data appears to be a reasonable proxy for what would result under severe salmonberry competition. The 50 percent difference in tree survival at age seven years (75 percent versus 38 percent) will be used to model the "no vegetation management" situation.

As with the alder complex, reforestation surveys (Plantation Survival and Growth Report, and Silvicultural Accomplishment Report) for the Siuslaw and Olympic Forests indicate that plantation

failure rate is negligible when reforestation is timely following site disturbance.

The short-term studies referenced above indicate reduced seedling growth in the absence of vegetation management. While both seedling height and diameter increment effects are seen, diameter growth appears to provide the most consistent correlation between salmonberry control and a release effect. A generalization can be made, in fact, that in all vegetation communities, the conifer diameter growth response is the most reliable morphological feature in prediction of future yield effects.

Factors such as physical or chemical damage to individual tree leaders during release, animal browsing,-"shock" effects, or differential tree growth in response to competition (for example, etiolation—increased height growth in proportion to diameter growth in seedlings receiving insufficient light) can temporarily set back the height response. Stein (1986), in a research progress report, finds significant differences in diameter growth after four years between treated sites and a control. However, no differences in height increment are observed. Released sites in this study show a 50-plus percent increased diameter increment after four years; an average of 53.7 millimeters (mm.) for treated sites, compared with 35.5 mm. for a "no release" site.

A study reported by Harrington and Wagner (1986) indicates growth trends under several release treatments. Diameter increment, in this case, was significantly greater after three years only under a "complete removal" treatment. Comparison of more operationally realistic prescriptions (one manual and three different herbicide-use sites) shows no significant diameter or height increment differences when compared to an untreated control.

Seedlings planted in well-established salmonberry, however, can suffer severe growth reduction and vigor loss. Newton and White (1983) found each year's delay in planting of salmonberry threat sites compounded losses from competition, compared to a site vacant of brush. Competition added .4 years, 1.5 years, and 4.1 years to the time required to reach a height at which trees may be considered "free-to-grow" from plantings in 0-, 2-, and 4-year-old salmonberry, respectively.

Several studies have been designed to show the relative increase, or encroachment, of herbaceous vegetation on released salmonberry sites. The removal of salmonberry and associated species will encourage an increase in annual plants and grasses. In this situation, on sites not subject to a severe summer drought and moisture stress, weed and

grass control is generally not a critical limiting factor for establishment of Douglas-fir plantations. On interior Coast Range and Cascade Range sites, however, lack of timely herbaceous vegetation control has been shown to translate into adverse survival and growth effects by both Gratkowski et al. (1979) and Preest (1977).

Gourley et al. (1986) examined the relationship of herbaceous weed control and tree growth in an Oregon Coast Range study. The objective was primarily to determine whether several animal damage protective treatments lead to enhanced growth of planted Douglas-fir. Seedling growth and mortality differences on weeded and untreated sites were also measured.

Sites were characterized by an "abundance" of bitter cherry, bigleaf maple, elderberry, western bracken, and salmonberry. The herbaceous component consisted of various grasses, plus thistles, tansy ragwort, and other weed species. All units had a substantial component of hardwoods and brush in addition to stands of Douglas-fir mature enough for logging. Sites were planted with transplants (2-1) following clearcut harvest and site preparation (broadcast burn or pile and burn). The weeded plots then received five herbicide applications (four of glyphosate and one of atrazine-dalapon) over the first three years. Control plots received no release treatments.

Measurements after five seasons indicate that weeding had gained one year in stem volume in comparison with no treatment. Volumes of weeded trees averaged 2.3 times those of unweeded trees. Fifth-year height of weeded and protected trees showed a .37 meter (m.) gain, and diameter showed an increase of 1.6 centimeter (cm.), compared to controls. Authors conclude that weeding to eliminate grass and herbaceous competition has a strong positive effect on seedling growth and can help evade animal damage. Seedling survival was not influenced, being approximately the same on all sites.

The intensity of vegetation control displayed in this study (site preparation plus five herbicide applications during the three years following planting) is not an operationally realistic management prescription on National Forest lands. Complete elimination of all competing vegetation for five years is neither practical nor even desirable. Growth objectives defined by managed yield table projections for Forest land management plans can be met without a "bare ground" management intensity. On some salmonberry-influenced sites, in fact, palatable grass species are sown in conifer plantations in order to enhance wildlife forage.

The Gourley et al. (1986) observations do, however, emphasize the

dynamic interaction of the shrub and herbaceous components within new plantations. It also establishes that total vegetation control can influence seedling growth (in comparison with a complete lack of control) in conditions where moisture is not normally considered a serious limiting factor.

The Stein (1986) Research Progress Report (FS-PNW-1201-8029) appears to represent a typical severity of salmonberry competition. The average height and diameter increment trends in this study will be projected for comparison of effects due to the absence of vegetation management.

Reforestation of salmonberry-influenced sites can be complicated by animal damage problems that are directly related to the intensity of vegetation management. The failure to control both vegetative competition and habitat for mountain beavers, rabbits, or hares can result in poorly stocked holes in young stands.

Perry et al. (1985) identifies the need for more knowledge of both salmonberry growth patterns and competitive effects on conifers. Aggressive site occupancy and exclusion of conifers by species such as salmonberry, thimbleberry, bracken fern, and vine maple, has been observed. However, with current state-of-knowledge, it is difficult to establish threshold values for significant competitive effects to conifers.

Step 2 Yield Comparison

A 90-year rotation with intermediate stand entries is representative for intensively managed salmonberry-influenced sites. Using the Stand Project System model for yield projection, the volume loss associated with an absence of vegetation management is approximately 21 percent. (See Attachment 12 for prescription and growth simulation detail.)

Step 3 Area Expansion

There are approximately 195,100 acres of this vegetation type allocated to "full-yield" management in the Region.

Step 4 Herbicide Efficacy

Few studies have been designed to show the relative effectiveness of herbicides and nonchemical methods in the control of salmonberry. Manual cuttings, glyphosate, fosamine, and a manual-plus-fosamine treatment are being analyzed on Coast Range sites by Stein (1986). Intermediate results after four years indicate no significant differences in chemical or manual release in terms of survival and growth.

A Coast Range Site Preparation Study Progress Report by Stein (1986) indicates no significant difference between fifth-year survival in manual, chemical, and broadcast burn treatments under a moderate level of brush competition to protected (tubed) seedlings. In both

height and diameter growth, trees in broadcast burn treatments showed greater gains than for the other treatments.

In a companion study, Manual and Chemical Options for Releasing Douglas-fir (Stein 1986), fourth-year results indicate that release treatments had little effect on tree survival or height growth, but did have some significant effects on diameter growth. In this case, three intensities of manual cutting showed the highest percentage of diameter increment gain (484 percent) compared to aerial glyphosate (461 percent) and fosamine (465 percent) applications.

Harrington and Wagner (1986) report third-year growth and survival following three chemical treatments and a manual treatment on Oregon and Washington Coast Range sites. This study was conducted in young brushfields, with only moderate amounts of overtopping brush. None of the operational release treatments (glyphosate, triclopyr, or manual cutting) have significantly increased Douglas-fir height or stem diameter growth above the untreated control.

With limited information, there is insufficient evidence to indicate growth and yield differences between vegetation management techniques in the control of salmonberry competition. Use of herbicides, particularly glyphosate, has proven an effective tool for dealing with excessive salmonberry and herbaceous vegetation.

Manual cutting of salmonberry and associated sprouts has shown satisfactory results (i.e., met prescription objectives), particularly on the Siuslaw National Forest. Treatment specifications have not been defined as thoroughly as have those for alder cutting. Salmonberry control involves the severing of numerous small stems from a common root burl. Therefore, cutting must be deferred until brush stems are large enough to deal with efficiently. Seasonal treatment "windows" similar to those used in alder control are needed for Coast Range shrubs such as salmonberry.

Control of an herbaceous component can be done more efficiently with chemicals in comparison with hand scalping or grubbing. The Gourley et al. (1986) study identifies a five-year growth enhancement through total chemical vegetation control in comparison with unreleased controls.

The potential for a difference in relative treatment effectiveness may lie in a slight delay (two or three years) in dominance of crop trees over the herbaceous component in some non-chemical techniques. In other words, it will take a bit longer for trees to develop the rooting depth and canopy closure to outstrip the grass and weed

influence. A basis for rotation-length yield reductions in Coastal conditions is essentially dependent on two questions:

1. Can Forest Plan yield projections be met while accommodating a low-to-moderate level of early herbaceous site occupancy?

2. Are differences in treatment efficacy such that chemical grass and weed control on moist Coastal sites will translate into a measurable and consistent yield effect?

As previously mentioned, Forest Service managed yield tables do not reflect total vegetation control during early stand development. There is simply too little information available, however, to answer the second question. The potential influence of an herbaceous component on Coast Range sites is clearly not as severe as it is on more interior, moisture-limited sites. Herbicide grass and weed control has the advantage of a longer duration of control than does manual treatment. In addition, whole area manual control of established grasses is unlikely to be operationally feasible on a broad scale (even if treatment cost is disregarded). Differences in treatment effectiveness will be sensitive to site-specific operational factors and, therefore, difficult to characterize.

It is felt that yield losses due to lack of availability of herbicides cannot be reliably shown for this vegetation complex. In addition to uncertainty about the importance of the herbaceous component on moist sites, the difference in basic management philosophy between public and industrial forest owners must be taken into account (i.e., multi-resource objectives preclude the Forest Service from using the "bare ground" style of vegetation management as a typical prescription).

Step 5
Area Expansion

No measurable yield reduction due to the suspension of herbicide use can be shown for the salmonberry type.

Ponderosa pine/grasses-herbaceous Analysis

Step 1
Information Review

This is a broad model for a vegetation complex that includes some diverse plant associations in eastern Oregon and Washington. Ponderosa pine generally predominates in association with species such as lodgepole pine, western larch, Douglas-fir, white pine, or true firs. Shrub species such as manzanita and bitterbrush can often be important components. There is a sizable body of information dealing

with pine establishment on grassy sites in the Pacific Northwest, and more generally, in the entire Western United States. For this reason, the pine-grass complex will be used as a broad proxy for these diverse vegetative conditions. Another general characteristic of this type is the relatively low site quality in comparison with the other complexes being analyzed.

Several studies have documented both mortality and reduced tree vigor on drought-prone sites with the absence of grass and forb control in new plantations. In a ten-year trial by Crouch (1979) in south-central Oregon, two fall herbicide applications doubled survival (55 percent versus 25 percent) and significantly increased heights (222 cm. versus 150 cm.) of released pines. Several shorter-term results by Baron (1962), Christensen et al. (1974), Dimock et al. (1983), and Bickford (1965) have shown stocking reductions. A Tahoe National Forest administrative study of grassy, unreleased pine plantations is reported by Fiske (1984). Average trees per acre stocking in these 0- to 20-year-old stands was 68, with only 48 percent of plots meeting minimum acceptable stocking standards. Seedling survival tends to vary greatly in response to spring and early summer precipitation patterns for any given season. Tree mortality due to weed and grass competition appears to be particularly responsive to the severity of competition.

White (1988) evaluates competitive effects on growth of juvenile Douglas-fir and ponderosa pine due to manzanita and herbaceous vegetation. Stem volume of three to five year old pine was about 670 cm3 at high levels of manzanita competition (biomass), compared with 1310 cm3 with no competition. This study also displays the dynamic interaction of shrubs and herbs. The general trend shown is that the higher the manzanita density, the lower the beneficial effect of removing herbs by hoeing. In some situations, herbaceous vegetation depressed conifer volumes more than did high densities of manzanita. The study location is the interior foothills of the Siskiyou Mountains.

At high elevations, the early control of herbaceous vegetation in reforested units will remove the food supply of pocket gophers, which can result in reduced tree mortality. When used at the proper scale and time, grass/forb control can effectively limit plantation damage due to rodent populations (Crouch 1979). Effective gopher control will normally require vegetation control in and near the planting site. Baiting and trapping have proven effective when used in combination with measures to limit the food source, and can also discourage migration into the site. This generally means that vegetation control must be integrated with direct control measures.

With no vegetation control in this complex, the 50 percent seedling loss within the first five years in the Crouch (1979) study appears to be a representative figure. Under intense grass and weed competition, however, 70 to 100 percent mortality figures have been reported in annual plantation monitoring surveys conducted by the East-side Forests.

Annual and perennial grasses have the potential to quickly occupy a large volume of soil and to initiate root growth earlier in the spring than do competing conifer seedlings (McDonald 1982). On sites where soil moisture is limiting, seedling vigor may suffer for extended periods until an adequate rooting depth is reached by the conifers.

Diameter growth reduction in the absence of early grass and forb control has been reported by Gordon (1962). This study in sapling- size pine shows a potential 39 percent increase in radial growth after five years. Crouch (1979) shows a possible 38 percent greater height response at ten years with timely grass/forb control. Fox (1985), in a progress report, displays ninth-year results in a 25-year-old pine stand with a dense understory of snowbrush, manzanita, and chinkapin on the Winema National Forest. Cubic volume underbrush control in this case is 38 percent greater (1,022 cubic feet versus 788 cubic feet) in comparison with the untreated control.

The threshold level for competitive growth and mortality effects due to grass density is displayed by Petersen (1985). At low levels of grass density (Leaf Area Index), competitive stress is apparently sufficient to reduce stemwood growth of some trees, but not severe enough to cause mortality. This is attributed to the ability of ponderosa pine to change patterns of photosynthate allocation from stemwood production to root production in order to tap water stored at deeper soil layers. Under severe competition, however, Peterson implies that substantial reductions of herbaceous cover are needed before resources are made available to alleviate the density-dependent stress in seedlings.

The study by Gordon (1962) displays growth suppression likely to be shown in grassy pine plantations. This study shows a potential 39 percent increase in radial growth after five years, and Crouch (1979) indicates a 38 percent greater height response at ten years with timely grass and forb control. These growth trends will be projected to display short-term effects due to an absence of vegetation management.

Step 2 Yield Effects

Yield comparisons were made with Prognosis—the SORNEC variant (Johnson, et al. 1986). A 100-year rotation with two intermediate entries is typical of intensively managed pine stands. Using the

assumptions described, no vegetation management will result in a 52 percent per acre yield reduction. (See Attachment 12 for prescription and growth simulation detail).

Step 3 Area Expansion

Approximately 1,436,200 acres of the pine-grass community is allocated to "full-yield" timber management. The predicted 52 percent change in long-term sustained yield on this land base is assumed in the absence of vegetation management.

Step 4 Herbicide Efficacy

In plantations with severe grass and forb competition, herbicide unavailability will translate into a yield effect. Effective site preparation can be obtained through a variety of methods in this vegetative type, or where steep slopes are seldom a limiting factor. Plantation site preparation and release for survival or growth has generally been accomplished through herbicide use, mechanical treatment, manual weeding and grubbing, and the forced grazing of cattle.

The use of cattle as a silvicultural tool is best suited to sites with an understory of palatable grasses. Timing and control of the treatment is critical, since reduction of the forage species can result in greater damage to trees. Doescher (1987) reports significant tree growth enhancement (both height and diameter) on a grazed plantation three years after grass seeding. Results on this south-central Oregon site also revealed that when grasses surrounding seedlings were grazed, water stress was similar to that found for seedlings grown on sites where herbaceous competition was controlled by herbicides.

Timely site preparation has proven to be critical in pine plantations within the East-Side and Transition subregions. Mechanical site preparation has been the dominant technique on East-Side forests. Ross et al. (1986) evaluated mechanical and chemical site preparation treatments on an East-Side Cascade site in south-central Oregon. Pre-existing vegetation was dominated by greenleaf manzanita, snowbrush, bitterbrush, and a variety of grasses. Eight years after treatment, the pine survival was comparable on the chemical (glyphosate), disk and chemical, disk and brush-blade treatments at 79 to 87 percent, compared with 30 percent on the untreated control. Annual height increment and tree volume (biomass) were statistically similar (0.05 level) on the chemical, chemical plus disk,and disk only treatments. Negative effects to upper soil zone properties (carbon and nutrient concentrations) were most severe with the brush-blade and chemical plus disc treatments. The study results indicate that appropriate site preparation treatments can significantly increase the survival and growth of planted pine in south-central Oregon.

Reinvasion of new plantations by grass and weeds is highly variable on sites east of the Cascade Crest. The potential for rapid site occupancy, particularly by annual grasses and sedges at higher elevations, has been documented by several authors, including Gordon (1962) and McDonald (1982). Grass species differences have been shown to be an important factor in tree seedling moisture stress (Baron 1962), both because of grass growth qualities and the species selectivity in grazing by cattle.

The need for release from grass-forb competition is related to the amount of competing vegetation. A threshold level for effects due to grass competition in ponderosa pine plantations has been indicated in work by Peterson (1985) and others. An estimate, based on experience of East Side Forests, is that approximately 20 to 30 percent of plantations in the pine/grass community will require a release treatment, as well as site preparation, for acceptable early stocking and growth.

On sites where grasses are well-established, spot scalping or grubbing will not control moisture competition in subsurface soils due to the extensive grass root systems. This means that a complete area treatment would be necessary for the desired release effect in these situations. Even if treatment cost is disregarded, large-scale, full-area grass removal in existing plantations is unlikely to be operationally feasible.

Alternative methods, such as the prolonged or forced animal grazing, can be effective. However, limitations imposed by herd or band availability—and the large administrative impact of these projects—tend to militate against a widespread reliance on grazing for plantation release programs. Doescher (1987) stresses that not all forested areas are suitable for the use of livestock as a silvicultural tool. Cited are limitations such as steep terrain, lack of palatable forages, and absence of water or salt which can make a site unsuitable for controlled cattle use.

It is estimated that an operational release program using manual and biological methods could accommodate approximately two-thirds of the grass control needed to release intensively managed east-side pine plantations. This means that approximately 478,700 acres would be untreatable in the absence of herbicide use. For modeling purposes, a management scheme similar to that used for "no vegetation management" has been used. In other words, a failure to use herbicides on these particular acres will have the same consequence as "no vegetation management."

Step 5 Yield Effects

A simple proportion will be used to estimate yield reductions in the absence of herbicide availability in grassy-pine plantations. Based on the operational constraints described in Step 4, roughly 8 percent of the acres in need of plantation maintenance will be untreatable in the absence of chemical release (33-1/3 percent untreated x 25 percent in need of release). This means that a potential reduction in long-term sustained yield of 4 percent will be associated with the suspension of herbicide use (8 percent of area untreatable x 52 percent yield reduction due to no vegetation management).

On a Region-wide basis, under the assumptions used (substitutability of techniques, cost factors nonlimiting, and timely reforestation following site disturbance), the lack of chemical use in this vegetation complex would involve only modest yield reductions. This effect can be significant locally, however, on several individual Forests within the pine subregion.

Douglas-fir-ponderosa pine/Ceanothus spp./herbaceous Analysis

Step 1 Information Review

Snowbrush (*C. velutinus*) is a widespread and silviculturally important component of many conifer stands. Deerbrush (*C. integerrimus*) is locally important in southern Oregon and has been evaluated in several studies. Both species can be aggressive sprouters following site disturbance, and can maintain large seedloads in litter and surface soils. This vegetation complex also serves as a proxy for some diverse plant associations in southern and eastern Oregon. Snowbrush is a permanent member of various plant associations and has characteristics which are particularly important in the fire cycle. (Zavitkowski and Newton, 1968). Germination largely depends on a mechanism such as heat for cracking the hard seed coat. In the absence of heat, seeds may remain viable in litter for several hundred years. Zavitkowski and Newton (1968) report observations that suggest that decadence in old snowbrush stands appears at about age 15 years. In general, reports suggest that brush will be shaded out by conifers after 10 to 30 years.

Site reoccupancy is normally the result of old seed stored in the soil. For this reason, effects on conifer seedling survival can vary greatly, depending on treatment or disturbance of stands influenced by these shrubs. For example, in stands of deerbrush resulting after wildfire (severe site disturbance), McDonald and Fiddler (1986) found differences in fourth-year survival—89 percent versus 42 percent—between released and control conifer plots. On sites more representa-

tive of normal timber management regimes, early stocking losses due to Ceanothus competition have not been severe. Gratkowski and Lauterback (1974) and Stein (1986) either found tree mortality to be insignificant or related mainly to factors such as animal damage.

A paper by Zavitkowski et al. (1969) shows the importance of timely planting after harvest and burning of snowbrush-dominated sites. Mean third-year survival (of Douglas-fir, ponderosa pine, western hemlock, and noble fir) was 75.0 percent on sites planted immediately (brush age 0), compared with 32.8 percent when planted in older snowbrush (up to 15 years old). Zavitkowski also notes that snowbrush achieved full site occupancy at about ten years, causing serious suppression thereafter. This study on the west slope of the Oregon Cascades also found that height growth of six conifer species (that would normally develop on the sites) was reduced by one-half under suppression by snowbrush. The findings indicated that snowbrush is more detrimental than beneficial (due to nitrogen enhancement or action as a nurse crop) in forest regeneration on these sites.

Walstad et al. (1986) compare treated (released) and untreated *Ceanothus velutinus*-influenced sites which were logged in the 1960's. Douglas-fir stocking and diameter growth were reduced on the untreated site. Growth simulations (DFSIM) with final harvest at age 60 years indicate a 13 percent volume reduction—9.9 cubic feet/acre (c.f./ac.) versus 11.4 c.f./ac. in the unreleased stand. In this study, product value (expressed as net stumpage value) shows a large proportionate difference between stands: $13.7 per thousand board fee per acre (M/Ac.) versus $9.2 M/Ac.

Growth and form effects resulting from moderate to severe snowbrush competition are well documented.

Early work by Dahms (1950) in snowbrush and manzanita shows significantly reduced height growth in unreleased seedlings. Height response, however, has tended to be inconsistent because of shock effects, physical leader damage, or animal browsing after release. Gratkowski (1979) found most of the height increment response to occur in the second five-year period following treatment. Trees initially eight feet tall at time of release in this study showed 1.2 to 1.4 times the growth of the trees growing in mature snowbrush. Gratkowski and Lauterbach (1974) estimate that release from snowbush on their study sites will save eight years in reaching a 20-foot average tree height.

Wilson (1985) evaluates hand pulling of snowbrush on a Willamette National Forest site which was planted one season following site

preparation (broadcast burn). Three manual treatments (100 percent pulling, removal of snowbrush within three foot radius, and removal of plants larger than eight inches in height) are compared with an untreated control plot. After eight growing seasons, no significant Douglas-fir height or diameter growth response differences were observed (at the one percent and five percent probability levels). The author emphasizes that the study represents one site on the McKenzie Ranger District. Conclusions reached are: (1) release from ceanothus may not be necessary if planting is timely following site preparation; and (2) treatments of 100 percent pulling may not be needed in order to meet release objectives.

Sanders (1983) presents monitoring results of manual brush cutting on sites distributed across the Willamette National Forest. Competition is primarily snowbrush ceanothus, with lesser amounts of vine maple and varnishleaf ceanothus.

After one growing season the released seedlings and saplings showed a height growth depression on seven of the ten stands. After three seasons, however, released trees showed a significant growth response in comparison to unreleased trees. At the end of five years, released trees were still above the brush, and were growing significantly better than trees that were not released. In addition, released trees showed greater resistance to damage from heavy, wet snows. Sanders gives the opinion that in old brush fields where conifers are well-established, one cutting appears to insure release. Where both the trees and ceanothus are young, however, one cutting will probably not release the trees.

Diameter increment has shown to be a more reliable measure of competition and response than has height growth in work by Gratkowski (1979), Peterson and Newton (1982 and 1985), Chan (1985), and McDonald and Fiddler (1986). Fourth-year caliper of seedlings growing in the "entire area sprayed" were approximately 2.5 times that of the control in McDonald and Fiddler (1986). Gratkowski (1979) indicates a 40 percent increase of radial growth at ten years for the full exposure treatment (cut and stump-spray).

Peterson and Newton (1985) display the importance of dealing with both the shrub and herbaceous components. Fifth-year data shows significant increases in stem height, diameter, and stem volume on sites where snowbrush and forbs were sprayed while a diameter increment response only occurred when shrubs alone were treated.

Defining "typical" severity of ceanothus competition is difficult due to the highly variable site limitations, stand histories, and brush

densities displayed in the research. For example, extrapolation of results from northern California studies to the Central Cascades (where soil moisture is normally less limiting) can lead to an overstatement of growth and yield effects.

It has been shown that competitive effects of snowbrush and associated species can linger long after trees gain dominance in terms of crown position. Working in a thinned 12-year-old stand, Oliver (1984) found significant differences in fifth-year response when full brush removal was employed. This was on a relatively low-productivity site dominated by whiteleaf manzanita, a nonsprouting variety. Response, after 23 years, in suppressed 40- to 70-year-old saplings was found to vary significantly with snowbrush and manzanita control, following overstory removal and thinning in Barrett (1982).

The importance of early brush control is reinforced by several authors. Peterson and Newton (1982) conclude that trees which have grown in competition for as long as ten years will show little early response to release from snowbrush. The need for early snowbrush control in conifer plantations is also indicated in studies by Youngberg and Wollum (1976) and Gratkowski (1979). A consistent message from the literature seems to be that "the longer the suppression, the longer it takes for release."

Newton (1984) displays results from an Oregon Cascades study comparing four release treatments (chemical control of shrubs and herbs, spray of shrubs only, and no treatment) for five-year-old Douglas-fir growing in full or partial suppression from snowbrush. After three years, the volume response (measured as change in D-2-H) was 4950 cm3 on the shrub and herb controlled site, and 3083 cm3 on the shrub-only site, compared with 1194 cm3 for the untreated control. After three years, the differences between volume growths were continuing to increase rapidly.

Tree vigor and form effects related to competition from snowbrush and associated species are addressed in the literature. Gratkowski (1979) finds trees shaded by a dense shrub canopy to usually be slender-stemmed and fragile, with narrow crowns and sparse foliage. Seedlings growing on a deerbrush-influence site were found by McDonald and Fiddler (1986) to sacrifice stem caliper and live crown development for height extension. Horowitz et al. (1978) and Horowitz (1982) addressed an apparent anomaly of increased height growth when seedlings were growing near ceanothus plants. Sites in this case were selected at random from units scheduled for release.

Many trees in these studies were found to be healthy when grow-

ing in the presence of brush, and the need for release of treated units was therefore questioned. An observation is also made from the site-specific cases that enhanced soil nitrogen availability in ceanothus brush fields, and the potential for damage to nontarget vegetation make release through herbicide use of questionable value. In addition, many trees in these units were found to simply not be suppressed. This study by Horowitz has been questioned on the basis of covariation among the comparisons—that a mistake was made in confounding conifer location with site history. The general observations are useful, however, because of the large number of sites examined.

The question of trade-offs between control and the beneficial aspects of the Ceanothus component involves much uncertainty. Net effects over a full rotation are not certain. The relative value of biological nitrogen accretion on nutrient-deficient sites, compared with application of inorganic fertilizers, has likewise been poorly defined.

Walstand (1986), however, finds the importance of nitrogen fixation on Ceanothus spp. sites to not be well understood. Zavitkowski and Newton (1968) discuss several efforts to evaluate the role of snowbrush in the nitrogen economy of timber growing sites. In summary, they suggest that the nitrogen fixation capacity of snowbrush decreases with increasing soil fertility and is of negligible-to-marginal importance on sites of moderate forest productivity. Conard et al. (1985) concluded that there is little proof that nutritional benefits would compensate for a growth loss due to brush competition.

As with alder nitrogen accretion, the benefits from Ceanothus spp. will probably be important on nutrient-deficient sites and of limited value on others. A moderate stocking level of snowbrush stems is often considered advantageous in operational stand prescriptions in the Pacific Northwest Region. In the absence of documented long-term information, the bulk of available literature appears to indicate that the typical net effect of a large shrub component in young plantations will be detrimental to conifer yields.

Conifer growth effects due to moderate and severe snowbrush competition can be persistent in comparison to some other shrub/forb complexes. This is particularly true of the variety C. velutinus v. velutinus , which can grow to a height of nine-to-ten feet. The Gratkowski (1979) data for trees initially eight feet in height at the time of release are considered representative of moderate levels of Ceanothus spp. competition. Height and diameter increment trends over ten years in this study will be projected for the short-term effects due to a lack of vegetation management. Diameter growth trends from the McDonald and Fiddler (1986) study represent a severe level of

ceanothus competition. These Hog Fire Area (Klamath National Forest) sites were severely impacted by wildfire and also contained a sizeable deerbrush component in the pre-disturbance stands.

This vegetation complex is located primarily in the southern Cascades and southwestern Oregon. Its extent and location mean that a moderate proportion of future reforestation efforts will also require dealing with older or well-established brushfields. An estimate is that this will be the case in 15 to 20 percent of reforestation efforts on ceanothus-influenced sites.

Replanting of failed plantations (and interplanting to bring stocking levels to acceptable standards) is necessary on a certain proportion of treated acres. Retreatment was needed on 17 percent of the planted acres, based on data in the 1987 Plantation Survival and Growth Report for Region Six. This tends to verify the estimate of 15 to 20 percent of reforestation efforts taking place under a more- severe-than-normal level of vegetative competition.

Seedling mortality under "severe" ceanothus competition will be weighted along with "typical" level of competition in order to display a representative condition throughout the vegetation complex. The average short-term conifer mortality is 10 percent (50 percent mortality on severely impacted sites, from McDonald and Fiddler (1986), times 26 percent of the reforestation effort in older or well-established brush). Stocking levels will be adjusted accordingly in the yield simulations.

Step 2 Yield Effects

A representative physical rotation with commercial thinning yields is 90 years in this complex for the Forest Plans.

Yield simulations using the Stand Project System indicate a 39 percent yield reduction due to an absence of vegetation management. (See Attachment 12 for prescription and growth simulation detail).

Step 3 Area Expansion

Approximately 912,600 acres of ceanothus-influenced sites are allocated to "full-yield" management.

Step 4 Herbicide Efficacy

Several manual and mechanical techniques have proven to be operationally effective in dealing with these seral shrub species. Unless root crowns are removed during mechanical site preparation, however, prolific resprouting may occur. Vigorous regrowth also can result following manual cutting, although pulling of ceanothus germinants and young plants has proven effective in very young stands.

The principal advantage of the use of systemic herbicides in con-

trol of ceanothus spp. is the inhibition of the potential rapid site reoccupancy. This creates a more manageable plantation. This difference in the duration of treatment effectiveness between herbicide and non-chemical methods will be of greatest importance in the 15 to 20 percent of sites with older or well-established ceanothus competition (i.e., on those sites involving fire rehabilitation or replanting of units with unacceptable initial seedling survival).

Differences in radial growth between seedlings treated by chemical and non-chemical means have been displayed for sites with a severe level of ceanothus competition. McDonald and Fiddler (1986) show significant differences in seedling survival and stem caliper (after four years) in deerbrush stands of fire origin. One manual treatment and three chemical treatments were compared.

Gratkowski (1979) also finds that tenth year radial growth differences can be seen in herbicide (aerial) and manual (cut and resprout) treatments of seedlings that are initially short in relationship to competing snowbrush plants. In both studies, the radial increment in manual treatment plots was roughly half of the response seen in the herbicide treatments. Conifer height growth, however, appears to be relatively unaffected and insensitive to ceanothus competition.

Relative changes such as this (a constant height growth, decreasing radial growth, and minor tree stocking reductions) are difficult to display in a stand projection model. For this reason, yield effects related to an inability to use herbicides will be estimated using the "no vegetation control" adjustment in Step 2 as a reference. We emphasize that this difference in treatment effectiveness will apply only on those sites where well-established, older brushfields exist or where fire rehabilitation is being attempted.

A simple proportion will be used in order to accommodate the differential radial and height growth effects shown in the McDonald and Fiddler (1986) and Gratkowski (1979) data sets comparing chemical and non-chemical treatments. In many tree volume equations, the periodic radial increment contributes approximately twice as much as does periodic height growth to stem volume in trees approaching the rotation ages typical of this vegetation complex. Examples can be seen in managed yield tables shown in Curtis et al. (1981). Using proportions then:

(15-20 percent of area in need of release treatment) times (67 percent volume adjustment related to diameter growth) equals 11.7 percent, or roughly 12 percent, of the adjustment shown for no vegetation management.

Therefore, 39 percent volume adjustment for no vegetation management (see step 2) times 12 percent equals a loss of five percent associated with the loss of herbicides in the ceanothus spp. complex.

Step 5 Area Expansion

There are approximately 912,600 acres of ceanothus-influenced sites allocated to full-yield management in the Pacific Northwest Region. This means that roughly 160,000 acres (the 15 to 20 percent with a more severe level of competition) will show a reduced treatment effectiveness in the absence of herbicide use.

Douglas-fir/tanoak-madrone Analysis

Step 1 Information Review

Tanoak, Pacific madrone, and associated tree and shrub species can present severe site competition to conifers in southwestern Oregon and northwestern California forests. Common hardwood associates on these sites include Oregon white oak, California black oak, chinquapin, canyon live oak, and bigleaf maple.

A number of environmental variables (common within the interior Coast Ranges and Siskiyou Mountains) can combine to create the potentially severe moisture stress for conifer seedlings. These variables include the severe summer drought, soils with limited moisture-holding capacity (due to depth or texture), and generally steep terrain. White (1985) identifies factors such as thin skeletal soils, hot dry summers, and aggressive herb and shrub competition as contributing to difficulty in establishment of conifer plantations in southwest Oregon. Minore et al. (1984) correlated environmental variables with regeneration success. That study found that soil depth, percent coarse fragments, history of slash burning, and southerly aspects were most often associated with poor regeneration.

The presence of a sizeable tanoak or madrone component in stands undisturbed by fire or logging indicates the potential for high levels of competition for conifer seedlings. Both tanoak and madrone develop quickly as seedlings and particularly, as vegetative sprouts. After three growing seasons, Strothmann and Roy (1984) found sprouts to average seven to ten feet in height and occur in clumps of 12 to 13 stems. The species can achieve tree form. Mature individuals generally are 50 to 90 feet tall. Individual tanoaks may be 120 to 150 feet in height on high quality sites.

Strothmann and Roy (1984) address the relative severity of tanoak and snowbrush competition. Twelve years after logging, some individual snowbrush plants had begun to die. Tanoak, however, was providing increasingly severe competition. The potential severity of tanoak

competition is also illustrated by Tappeiner (1985). In this case, tanoak potential site occupancy (measured in Leaf Area Index) is high in comparison to Ceanothus and whiteleaf manzanita.

While aggressive site reoccupancy is normally the result of vegetative sprouting, both tanoak and madrone produce copious amounts of seed at frequent intervals (McDonald 1978). Few of these seeds result in trees, but enough do to assure that hardwoods are a continuous component of the understory vegetation. Models have recently been developed for prediction of site occupancy by sprouting hardwoods (Harrington et al. 1983). This ability of broad-leaved sclerophyll species to produce new leaf surface area by sprouting following mechanical or fire damage contributed to the relatively high competitive ability of these species.

There is little information available regarding seedling mortality, due to long-term tanoak competition. Roy (1975) addressed tree vigor and crown position relative to brush canopy of the twinned trees after 17 seasons. Of the brush-grown trees, 55.6 percent are classed as vigorous compared to 100 percent of the open-grown seedlings.

Relative tree position shows a similar relationship, with 51.9 percent of brush-grown conifers in a dominant or codominant position, compared to 92.6 percent of the open-grown trees. There was also an especially high mortality in trees growing through the brush due to snow breakage. This factor may be related to the reduced vigor and form defect (etiolation) common in Douglas-fir grown under reduced light and severe moisture competition. The ability of individual tanoak and madrone to maintain height growth for long periods probably means that few of the overtopped trees will survive and maintain adequate growth necessary for the production of a commercial product.

The Brush Mountain Twinning (Roy, 1975 and 1981) represents a typical degree of competition and site history in tanoak-influenced sites. For this reason, a 40 to 50 percent seedling mortality is assumed in the absence of vegetation management. The study represents a direct comparison of trees growing in a brush-free area and a brush-grown situation. Reforestation efforts following site disturbance (logging) were made promptly in both situations.

The Roy (1975 and 1981) data addresses height growth effects. After 28 years, the average "brush-grown" trees had lost 12.4 feet in height, representing a loss of 8.3 years growth. Differences in height growth were slow at first, but the growth curves were continuing to diverge after 28 years. The Roy data, in fact, indicates that release effects will not be apparent until five-plus years following release.

Vigor differences—expressed as needle complement, color, and needle length—were apparent in brush-grown trees. After projecting the growth curves from this study, Fiske (1984) estimates a 12- to 13-year delay (40 years compared to 27 years) for the suppressed trees to reach 50 feet in height. This seems consistent with interim growth estimates made by Tesch (1985) after observation of seedlings growing in tanoak and manzanita sprouts. In this case, it would take approximately 25 years for seedlings in a hand-slashed area to reach breast height while Douglas-fir on a complete control site should reach the same height in less than eight years.

Diameter response has been reported in work by Owston et al. (1986). Fifth-year results from a Coastal portion of the Siskiyou National Forest show a significant diameter growth increase (15.5 mm. versus 10.9 mm.) of trees in chemically-treated plantations. Radosevich et al. (1976) evaluated Douglas-fir radial growth for ten years following a cut-surface herbicide control of tanoak and madrone. Trees receiving an overstory control showed a 260 to 451 percent increased basal area growth in comparison to controls. Third-year height and diameter response in bare-root seedlings growing under injected hardwoods (Hobbs and Wearstler 1985) was 70 to 80 percent greater than those grown under the untreated hardwoods.

The Owston et al. (1986) study appears to reflect a typical severity of competition and will be projected to display short-term radial growth effects.

Projections of height growth response by Fiske (1984) based on the Roy data will be used to display the short-term consequences of an absence of vegetation management.

Work by Tappeiner and Harrington (1985) reinforces the need for control of both herbaceous and shrub components in release efforts. Third-year results demonstrate an increase of stem diameter growth only with complete removal of shrub and herbaceous vegetation. The importance of herbaceous vegetation control during the early seedling establishment period is also implied in preliminary results by Hobbs and Wearstler (1985).

Tanoak trees have commercial value as a roundwood product, and tannin in the bark of some older trees is utilized. Hardwood markets tend to be directly related to the availability of sawmill residues for use in pulping operations. It seems unrealistic to anticipate a greatly expanded commercial demand and increased product values for tanoak in the near future, or at least within the time frame covered by a programmatic environmental impact statement.

Step 2 Yield Comparisons

A 90- to 100-year rotation, with commercial thinning, is representative of intensively managed stands is this complex. Comparison of growth projections using DFSIM indicate that the yield reduction associated with no vegetation management is 60 percent over a typical management cycle. (See Attachment 12 for prescription and growth simulation detail.)

Step 3 Area Expansion

There are an estimated 169,300 acres of this vegetative complex allocated to full-yieldmanagement on the Siskiyou National Forest and minor portions of the Rogue River and Umpqua National Forests. This represents about two percent of the total "full-yield" timberland component.

Step 4 Herbicide Efficacy

A large portion of the total historic herbicide use has occurred in the tanoak/madrone belt. Both species can sprout vigorously following fire or soil disturbance. Tappeiner and McDonald (1984) found that tanoak seedlings maintain a single stem for about 5 to 12 years, then form a burl with dormant buds below ground and produce new stems. The study also indicates that tanoak growing in an understory re-establishes slowly after burning. The implication is that tanoak control in 30- to 75-year-old conifer stands may effectively prevent the need for costly subsequent site preparation.

Mechanical removal of large root crowns is difficult without major site disturbance. The tough, leathery foliage discourages any significant browsing of tanoak, although the berries (madrone) and acorns (tanoak) are utilized by wildlife. The current season's growth of madrone is occasionally browsed by deer.

Manual release using power saws has shown mixed results. After working with canyon live oak, a common associate on relatively dry sites, Hobbs and Wearstler (1985) concluded that manual slashing of sclerophyll brush is not operationally realistic due to the vigorous resprouting and potential for physical damage to crop trees during the felling of hardwoods. Forest Service silviculturists in southwestern Oregon and northwestern California are having some success with manual tanoak control, although more than one treatment is often needed to meet release objectives.

The availability of contractors and an adequate labor pool are possible limiting factors for a greatly expanded manual release program within the "tanoak belt." This includes portions of the Klamath and Six Rivers National Forests in northwestern California, portions of the Medford District of the Bureau of Land Management, and the affected National Forests of southwestern Oregon.

Forests experienced some defaulted contracts and non-responsive bidding on manual release contract offerings after the 1983 Court injunction against herbicide use. In subsequent years, this problem was reduced as contracts were broken into smaller and more manageable bid items, and offerings became better coordinated between adjacent administrative units.

For purposes of this analysis, it will be assumed that a much-increased program of manual release from tanoak could be accommodated by careful program management and the gradual recruitment of contractors as the bid solicitations become more frequent and systematic. It must be emphasized, however, that labor availability can be a potential management constraint to an enlarged chainsaw-release program at the local level (see Appendix E, Silviculture Program Effects).

Herbicide release treatments must be timed precisely to accommodate differences in phenological development of target and nontarget vegetation (Gratkowski 1978, and Conard 1986). When properly used, however, herbicides have proven effective in both the degree and duration of tanoak and madrone control. The principal advantage of systemic herbicide use in tanoak control lies in the inhibition of vegetative sprouting in comparison with mechanical or manual treatment. Siskiyou National Forest records indicate that 1.5 chemical treatments have typically been used to meet prescription objectives (plantation certification). An average of two to three manual treatments, however, have been necessary to achieve comparable results on tanoak-influenced sites.

For reasons stated above, the amount and vigor of pre-existing tanoak is a major factor in the relative effectiveness of herbicide and alternative methods. It is doubtful that conversion of pure or nearly pure tanoak and madrone stands to conifer plantations will be successful (i.e., meet the tree survival and growth rates assumed in managed yield projections) without chemical brush control to limit resprouting.

The same limitation would apply in the regeneration of poorly-stocked conifer stands with a well-established tanoak component. This means that an estimated 50,000 acres of tanoak-dominated sites cannot be successfully regenerated in the absence of herbicide use (based on a survey of silviculturists on the Siskiyou, Rogue River, and Umpqua National Forests).

The yield effects related to a lack of vegetation control (shown in Step 2) are considered a reasonable proxy for efforts to regenerate these 50,000 acres of severe hardwood competition by nonchemical methods.

Based on assumptions used in this analysis (i.e., cost is not limiting, and reforestation is timely) chemical or manual treatments should both be effective where conifer was dominant in the original stand. This means that crown closure in the stand prior to disturbance (fire or logging) was predominantly conifer.

At this time, there is insufficient data to quantify differences between methods. The current prescription for manual cutting of tanoak on the Siskiyou National Forest is limited to a single treatment after conifers reach a mean height of 36 to 48 inches. This is a reflection of concerns for costs factors, buildup of fire fuels, and worker safety when working in heavy slash.

Studies being conducted by the Forest Service, Pacific Southwest Forest and Range Experiment Station, and the Oregon State University FIR (Forestry Intensified Research) Program are examining the effectiveness of various nonchemical controls of tanoak competition in conifer plantations. Knowledge gained in this research, plus the continuing efforts of Forest Service and other silviculturists, should help refine the stand culture and harvest techniques needed to meet management objectives in the tanoak complex.

Step 5 Area Expansion

The loss of herbicide use would result in approximately a 19 percent reduction in predicted long-term sustained yield.

(Tanoak conversion area divided by total tanoak area, times yield reduction due to "no vegetation management".)

50,000 Ac. (severe competition)

169,300 Ac. (total tanoak area) X .65 (No management yield effect) = .19

True fir-hemlock/shrub/herbaceous Analysis

Step 1 Information Review

Regeneration success has been variable in these higher elevation stands due to extremes in solar radiation, air temperature, and moisture stress which can be intensified by brush, grass, and herbaceous competition. Tree damage by rodents feeding in sedge and forb communities can also complicate the reforestation efforts. True firs (Pacific silver, subalpine, noble, grand, red, or white fir) are normally important components in a variable mixture of montane and subalpine tree species. Unfortunately, there is little information regarding competing vegetation beyond the seedling stage in this

vegetation type. Once established, hemlock and most true fir seedlings and saplings have the ability to maintain full crowns and the potential for a favorable growth response despite long periods of suppression. This advantage has been documented by Seidel (1983) and others. A variety of silvicultural systems and vegetation control techniques are being used in management of true fir.

After examining clearcuts in the east-side Cascades, Seidel (1979) identified an increase in grasses and forbs (along with the severity of burning) to be consistently associated with decreased tree stocking. Dimock (1981) has found significant increases in third-year survival of true fir when sedges and beargrass were controlled in herbicides—26 percent and 31 percent, respectively, compared with 9 percent and 14 percent on control plots.

Working with established white fir understory saplings in the Central Sierras, Conard and Radosevich (1982) indicate that a combination of dead shade and brush control can be a benefit to survival of true fir naturals because of the reduced evaporative stress. When no shade was provided, at least an 80 percent reduction of shrub cover was needed before growth effects were recorded.

In another Central Sierras study involving mixed conifers and montane shrubs, Lanini and Radosevich (1986) found white fir survival at year five to range between 41 percent and 52 percent on sites receiving mechanical or thermal site preparation. Survival on plots where herbicide applications had been combined with the site preparation treatments were consistently lower, due to the accidental exposure of sensitive fir seedlings during application. Tolerance to herbicide exposure varies greatly by tree species, type of herbicide used, and physiologic factors related to seasonal growth patterns (King and Radosevich 1985).

The number of potentially limiting environmental variables and variety of silvicultural schemes being used in the true fir-hemlock type make the quantification of tree survival and growth effects relatively uncertain. Often, the most competitive vegetation on these sites occurs in the early seral stage. This means that severe site disturbances, such as broadcast burning or machine piling of brush, can result in subsequent vegetation management and productivity problems.

True fir survival, in particular, appears to be related to control of grass-forb competition during the critical period of seedling establishment. A reduced trees-per-acre stocking level can be especially damaging to long-term volume yield on these sites which are capable of maintaining high stocking levels and favorable growth rates for long

time periods. Using data from Dimock (1981), it is estimated that seedling survival on sites receiving no vegetation management will be 35 to 45 percent of that on sites with early weed and brush control.

White fir height and diameter growth response in the King and Radosevich (1985) study was related to reduced shrub canopy volume. In this case, the "low" shrub canopy volume sites show a 22 percent larger height response (38.0 cm. versus 31.2 cm.) and 57 percent greater diameter (13.5 mm. versus 8.6 mm.) compared to fir on the "high" plots. The herbicide applications generally increased the amount of available soil water compared to plots treated nonchemically, regardless of site preparation methods (mechanical or thermal) used in combination.

There is no data available from central Cascades high elevation true fir-hemlock sites to use to display growth effects associated with an absence of vegetation management. The King and Radosevich data on white fir was taken at a central Sierra location. It will not be extrapolated for this analysis because of the inherent differences between central California and southern Oregon true fir stands. These include moisture gradient, species composition, and other site differences which can be inherent between central California and southern Oregon true fir stands.

True fir-hemlock sites in the northern Cascades will generally not contain a silviculturally important shrub or herbaceous component. For this reason, these acres have not been included in this analysis.

This means that differences in seedling growth between managed and unmanaged sites cannot be established for this vegetation complex. Therefore, only the tree mortality trends will be used in yield simulation comparisons.

Caution is needed in the use of thermal or mechanical treatments for these higher elevation sites. There is often a potential for damage to the soil resource, and thus a reduction in long-term site productivity. This is especially true of fragile sites where soils may be coarse or poorly developed, surface rock and coarse fragment common, or the available nutrient capitol concentrated in surface soils.

Step 2 Yield Effects

A 120-year rotation, with intermediate thinnings, is a representative management scheme for this type. The tree stocking effects (a 55 to 65 percent loss from Dimock, 1981) were used to display yield effects in growth simulations. An absence of vegetation management would result in an approximate yield reduction of 56 percent in comparison with full-yield management. (See Attachment 12 for prescription and yield simulation detail.)

Step 3 Area Expansion

Approximately 1,474,700 acres of this vegetation complex are allocated to "full-yield" management in the Pacific Northwest Region.

Step 4 Herbicide Efficacy

Herbicide use has been effective in operational programs for the control of shrubs, forbs, and grasses in young true fir stands. This is especially true when intertwined root systems of seedlings and sod-forming grasses preclude the use of manual grubbing and scalping.

Another factor which can complicate young stand tending is the need to control species such as sedges and lupine, which are desired feed for pocket gophers. In many situations, baiting and trapping gophers will not by itself limit conifer damage to acceptable levels. As with rodent control in the pine-shrub herbaceous complex, gopher baiting or trapping must normally be supplemented with vegetation control.

The explanation for an increased effectiveness of herbicide use for site preparation or release in certain true fir-shrub-grass complexes is similar to that used in the ponderosa pine-grass model. In some situations, alternative methods will provide satisfactory results. In other circumstances, however, herbicides can more effectively control competing vegetation. These situations, described previously, include a heavy grass or weed cover in proximity to crop trees, and also in areas where site variables limit the use of nonchemical methods. As in the pine-grass analysis, broad-scale, whole-area manual scalping of dense grass is considered operationally infeasible.

Step 5 Area Expansion

Based on a survey of Forests with large acreages of this vegetation complex, it is estimated that the unavailability of herbicides will limit treatment options and effectiveness on 10 to 15 percent of the total acres. This is due to either the severity of herbaceous competition or to site factors which preclude the use of fire and mechanical treatments.

The 1987 Plantation Survival and Growth Report was used to cross-check this estimate. Twelve Forests have a large acreage (between 50,000 and 288,000 acres) of full-yield lands within this vegetation complex. Eleven percent of the acres certified in third-year plantation exams for these Forests had required retreatment (either replanting or fill-in planting to supplement low initial survival). This appears to give a good correlation with the estimate of area affected by the unavailability of herbicides.

For modeling purposes, the growth effect on these "herbicide dependent" acres is assumed to be comparable to the "no management" scheme shown in Step 3, or a 56 percent yield falldown. Therefore, the potential long-term sustained yield effect due to the loss of

herbicides is estimated to be 7 percent or,

65% (no management yield reduction) X 12-1/2% (dependent acres) = 7%.

Information and Research Needs

In addition to the true fir-hemlock/shrub/herbaceous complex, there is little data and documented knowledge to quantify effects in several other extensive brush types. Two of the most prominent are the vine maple and ninebark-influenced areas. There is a need to better define the phenological characteristics and growth potentials of the vegetation, as well as their effects on conifer seedling development.

Vegetation management program research needs are well described by Walstad and Kuch (1987). Three phases of program improvement are identified. These are: treatment development and evaluation; treatment decision criteria; and problem prevention.

a. Treatment Development and Evaluation

This aspect involves the development of alternative treatments for control of competing vegetation, the evaluation of treatment cost and effectiveness, and the identification of biological and physical factors affecting treatment effectiveness.

b. Treatment Decision Criteria

Information needs include the relationship between stand growth and weed population density; evaluation of treatment timing and its influence on the necessary degree of control; incorporation of stand density influences on the level of competing vegetation effect in growth and yield simulators; and basic studies of tree and weed competitive interactions.

c. Problem Prevention

This aspect offers the best long-term opportunities for minimization of weed problems. Included is the evaluation of complete reforestation and stand management systems for reduction of weed vegetation problems. Another important area of study is in weed ecology (especially ecesis—the establishment of a plant in a new habitat) and the role of early seral species in nutrient cycling, nutrient retention, and maintenance of long-term productivity.

Much work addressing these management needs is being conducted by agency, industry, and university organizations. Cooperative

approaches with pooled resources are a likely trend because of the complexity of the problem and limitations of individual organizations.

Summary of Potential Timber Growth and Yield Effects

The following table summarizes timber yield effects, as they will eventually translate into changes in long-term sustained yield levels. A "no vegetation management" scheme is representative of program effects under Alternative C, while "no herbicide use" is represented by Alternative A.

Potential Long-term Sustained Yield Reductions (percent)

Vegetation	No Vegetation Management	No Herbicide Use	"Full-yield" Component (1,000 Acres)
Douglas-fir/alder	-25%	(Negligible)	236.8
Douglas-fir/hemlock/salmonberry	-21%	(Negligible)	195.1
Ponderosa pine/grass-forb	-52%	-4%	1,436.2
Douglas-fir-Ponderosa pine/Ceanothus spp.	-39%	-5%	912.6
Douglas-fir/tanoak-madrone	-65%	-19%	169.3
True fir-hemlock/shrub/herbaceous	-56%	-7%	1,474.7

Regionwide Effects on Timber Yields

The six vegetation complexes represent 54.2 percent of the full-yield suitable timberlands within the Pacific Northwest Region. Attachments 10 and 11 display the distribution by National Forest. Approximately 3,960,400 acres of intensively managed lands are not characterized by the vegetation strata used in this analysis. Information dealing with phenology and growth potentials, and effects on developing conifers growing in these plant associations is not sufficiently quantified for a reasonably comprehensive analysis.

In order to display Regional yield effects, some broad assumptions and extrapolation of data will be necessary. These "unaccounted" acres show the following geographic distribution:

Subregion	Forests	Acres (1,000)	Percentage
Washington	Olympic, Gifford Pinchot, Wenatchee, Okanogan, Colville, Mt. Baker-Snoqualmie	1,806.7	45.6%
Oregon East-side and Transition	Deschutes, Mt. Hood Winema, Ochoco, Wallowa-Whitman, Umatilla, Fremont, Malheur	1,018.7	25.7%
Oregon Coastal and South Cascades	Siuslaw, Siskiyou Umpqua, Willamette, Rogue River	1,135.0	28.7%

Broad generalizations can be made about the land base not accounted for by the six vegetative complexes. First, that the bulk of its occurrence (71.3 percent) is within the Washington or Oregon East-Side and Transition Subregions.

Secondly, that the relative need for vegetation management is typically not as great outside of the Oregon Coastal and southern Cascades Forests. This is related to factors such as a north-to-south moisture gradient, climate and precipitation patterns, soil waterholding potentials, and the severity of inter-species plant competition. In other words, as an average condition, the potential long-term yield reductions for these "unaccounted" acres should be at the low end of the range displayed in Table A-1.

A third general characteristic is that the bulk of the unaccounted acres occur outside of the Subregion where most of the historic herbicide use for silvicultural purposes has been seen. For example, five Forests (the Willamette, Siuslaw, Umpqua, Siskiyou, and Rogue River) typically accounted for 75 to 85 percent of the total silvicultural herbicide use in the five-year period between 1978 and 1982. In all likelihood, this Subregion also accounted for 90-plus percent of the herbicide use made primarily for improved treatment effectiveness (rather than for cost considerations). This means that potential yield effects associated with a loss of herbicides for site preparation and release on the "unaccounted" acres should be at the low end of the figures shown in Table A-1.

With an absence of vegetation management (Alternative C), the

range of minus 25 to 50 percent appears to characterize the likely Regionwide long-term sustained yield effects. This will translate into approximately a one billion to two billion board foot annual reduction from the levels shown in the Forest land management plans.

Yield effects with a permanent suspension of herbicide use (Alternative A) can also be estimated. In the analysis, the tanoak-madrone complex is clearly the most difficult reforestation prescription with an unavailability of chemicals. The potential long-term sustained yield (LTSY) effect in this case is estimated to be minus 19 percent.

Disregarding the tanoak-madrone type, a case can be made that the five remaining vegetative complexes are a reasonable proxy for the nearly four million acres still unaccounted for in the analysis. Given the low level of historic herbicide use in the Washington, Oregon Transition, and East Side subregions, this assumption may exaggerate the yield impact related to herbicide loss for these Forests. With a paucity of information to work with, however, this assumption appears to be a prudent approach to a Regionwide extrapolation and yield estimate. The weighted average long-term sustained yield reduction of the five vegetation complexes, other than tanoak-madrone, is 4.8 or minus 5 percent.

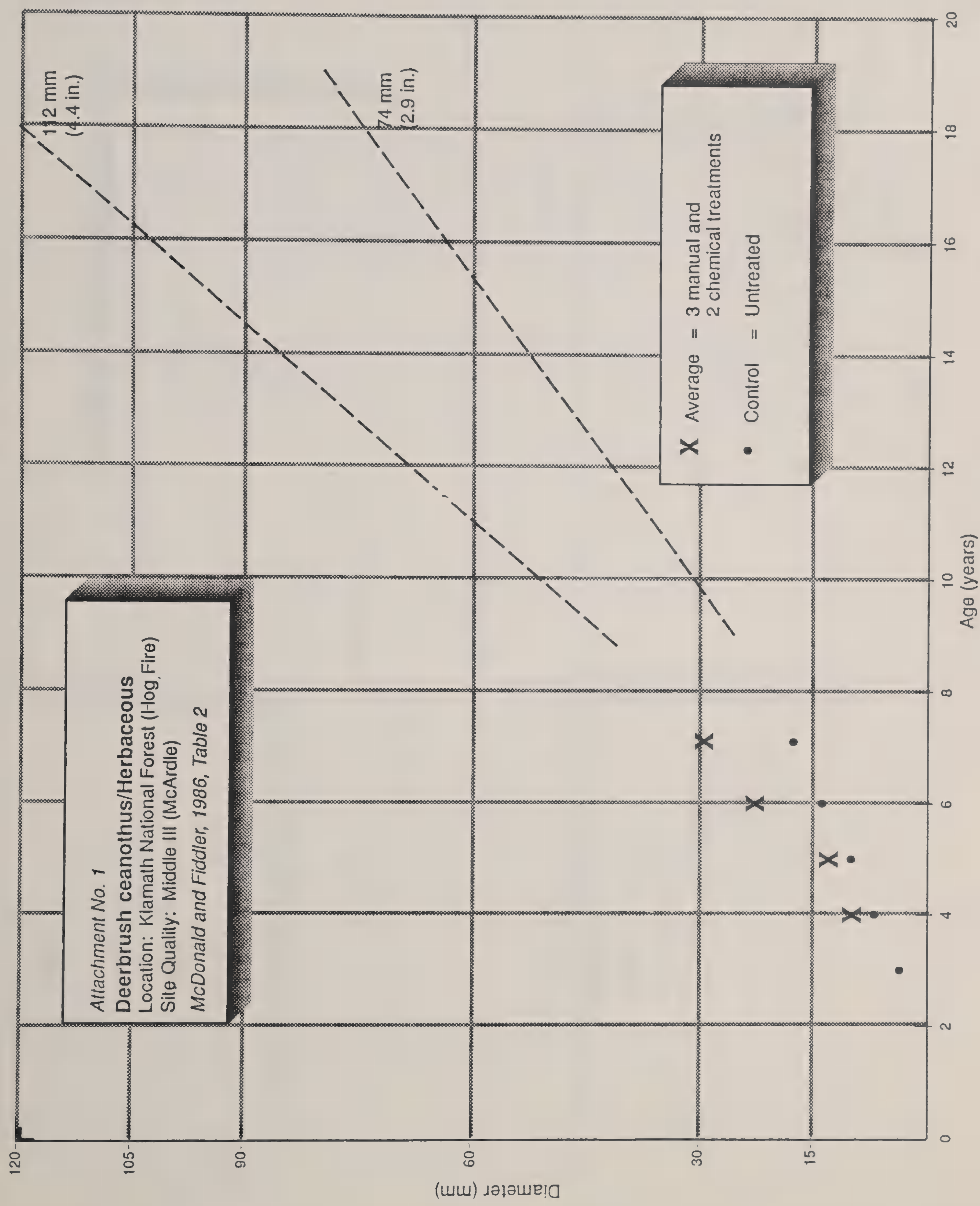
Table A-1
Potential LTSY Reductions (Percent)

Vegetation Complex	No Herbicide Use	Full Yield Component (1,000 acres)
Douglas-fir/alder	(Negligible)	236.8
Douglas-fir-hemlock/salmonberry	(Negligible)	195.1
Ponderosa pine/grass-forb	-4%	1,436.2
Douglas-fir-ponderosa pine/ceanothus spp.	-5%	912.6
Douglas-fir/tanoak-madrone	-19%	169.3
True fir-hemlock/shrub/herb	-7%	1,474.7
(Balance of Suitable Lands)	-5%	3,960.4

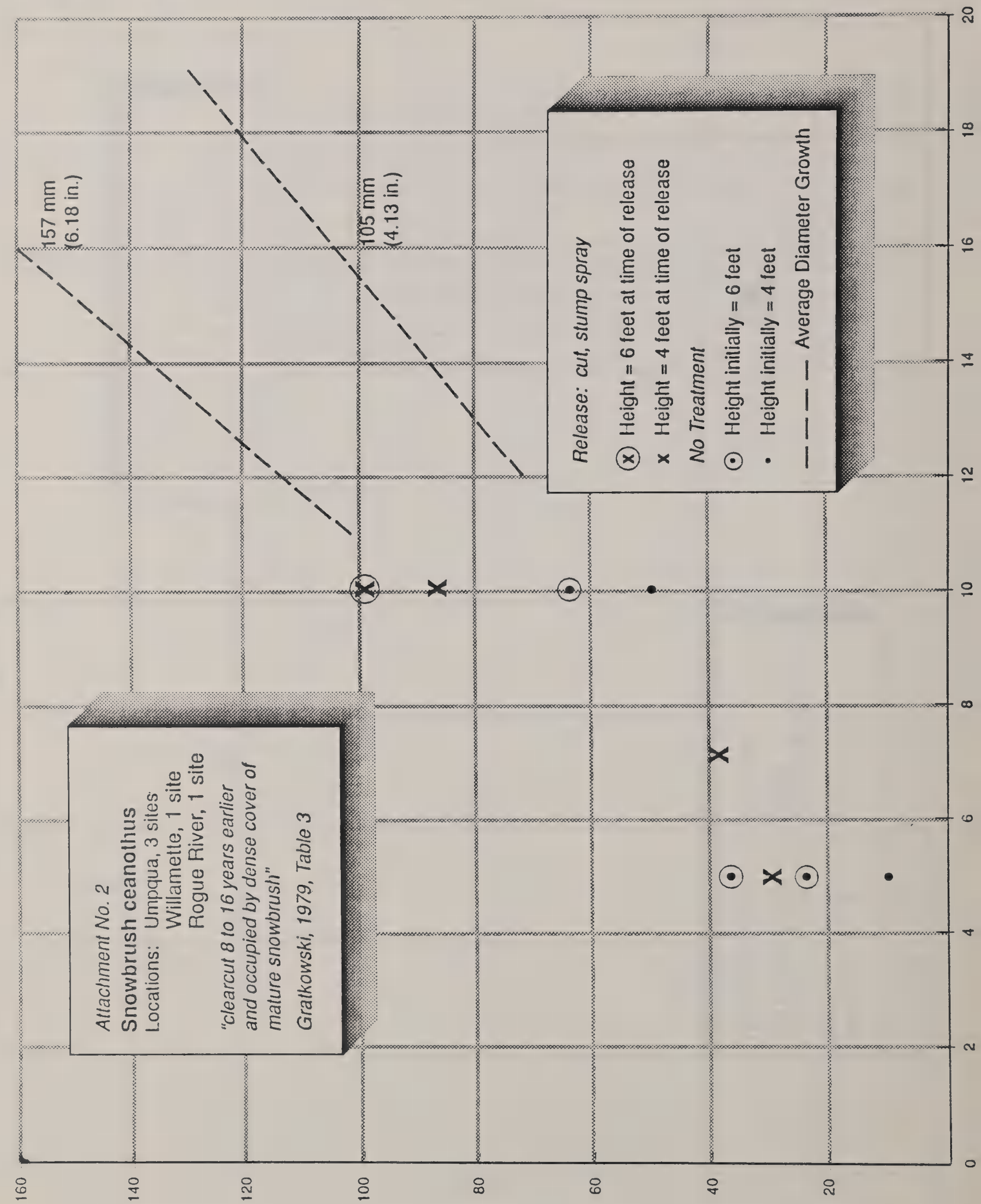
In the absence of herbicide use (Alternative A), the weighted average reduction in long-term sustained yield is, therefore, minus 5.2, or 5 percent. This would translate into an estimated 190 to 215 million board foot reduction from levels shown in the Forest land management plans.

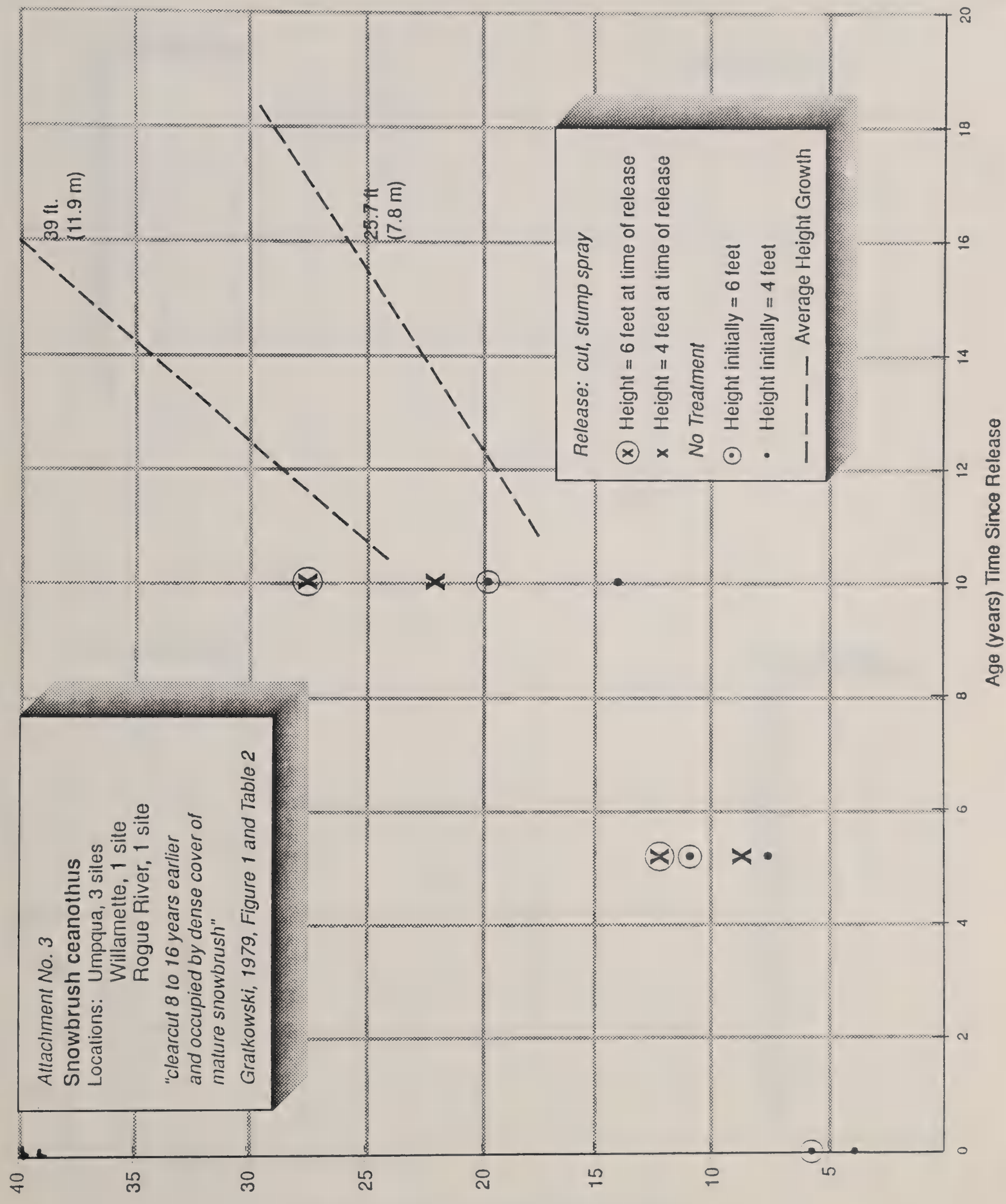
Actual harvest level adjustments, if necessary, will be assessed by each individual Forest. Only that component of the capable-available

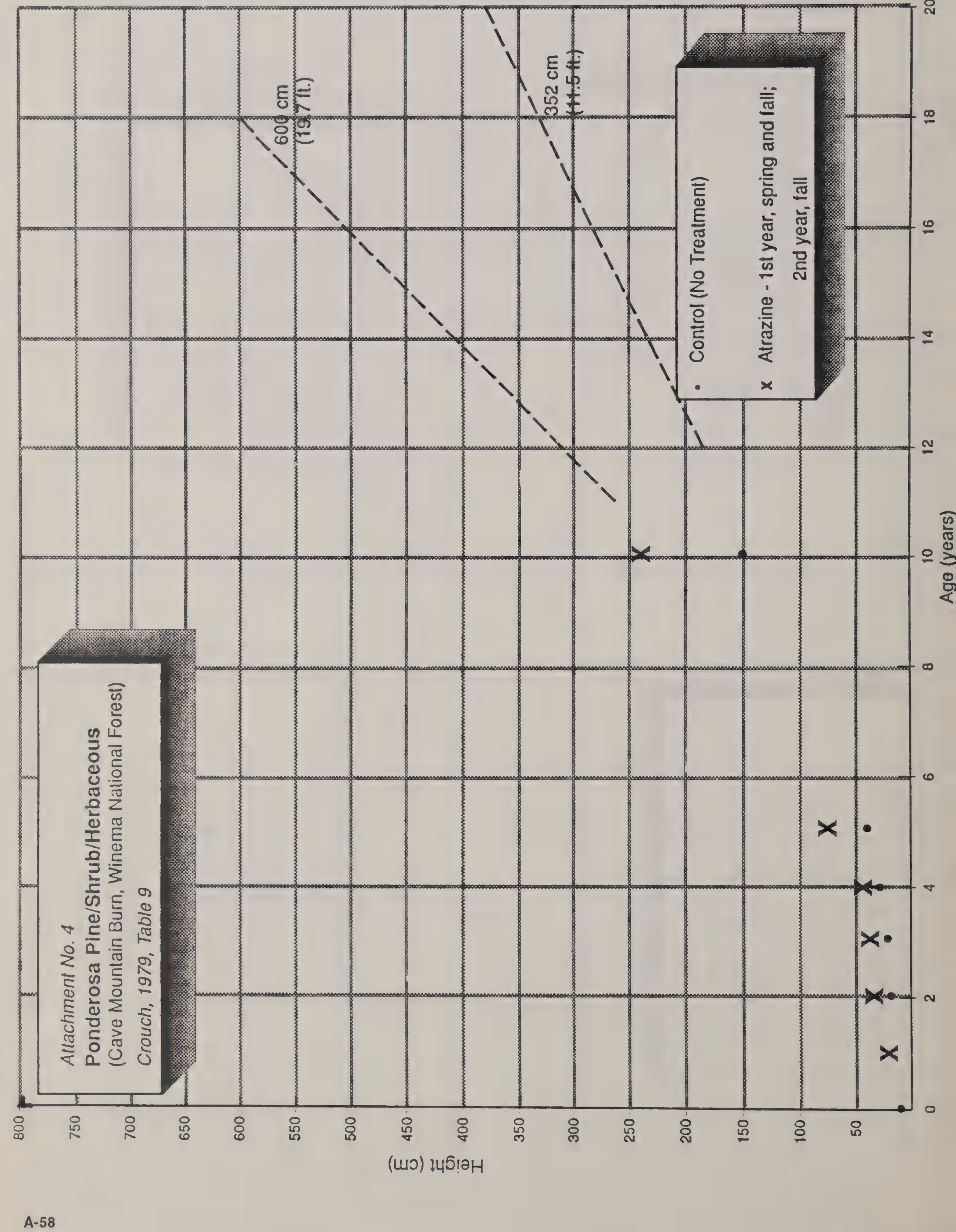
land base managed for timber yields approaching the full biological site potential will generally be affected. In many situations, the lack of vegetation management and/or herbicide use will limit the potential long-term sustained yield level achievable from a site. The relationship of the programmed harvest level—allowable sale quantity—under a Forest Plan to this potential (long-term sustained yield) will determine the need for adjustments in the current timber sale program. A discussion of Forest-level allowable sales quantity (ASQ) effects under the various alternatives is presented in Chapter IV (Environmental Consequences) of the EIS.

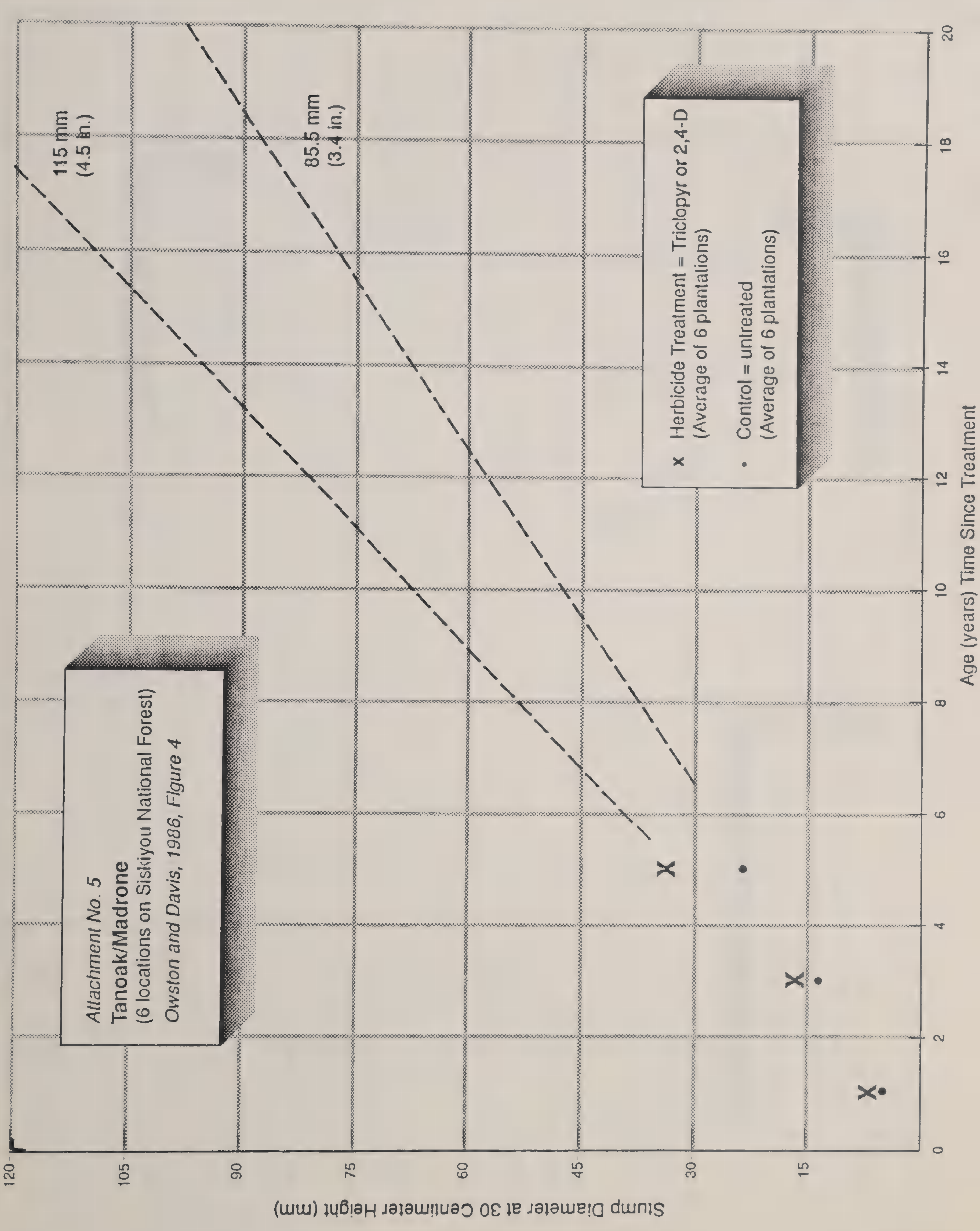


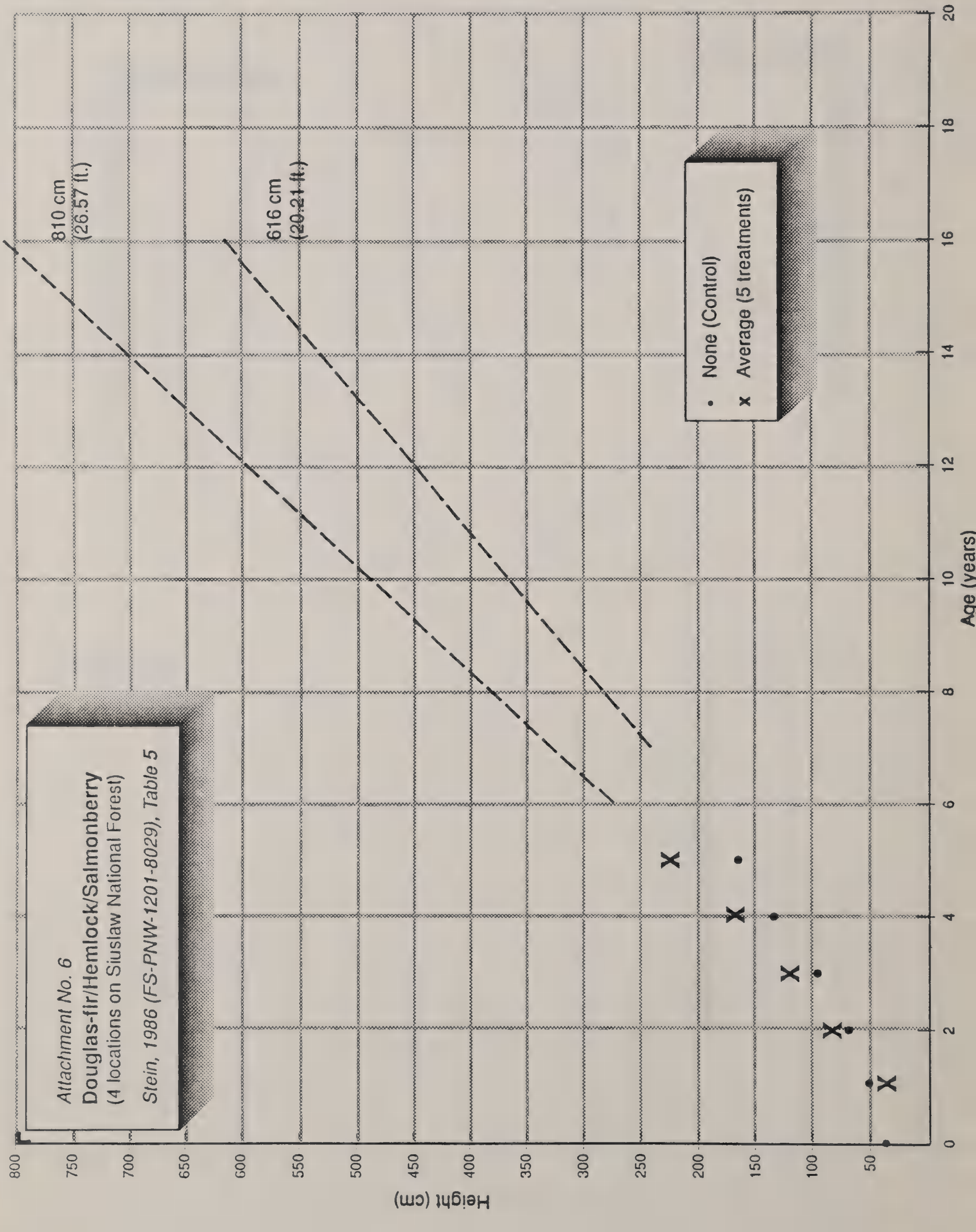
Attachment No. 1
Deerbrush ceanothus/Herbaceous
Location: Klamath National Forest (I-log Fire)
Site Quality: Middle III (McArdle)
McDonald and Fiddler, 1986, Table 2
112 mm
(4.4 in.)
74 mm
(2.9 in.)
X Average = 3 manual and 2 chemical treatments
• Control = Untreated
Diameter (mm)
120
105
90
60
30
15
0
2
4
6
8
10
12
14
16
18
20
Age (years)

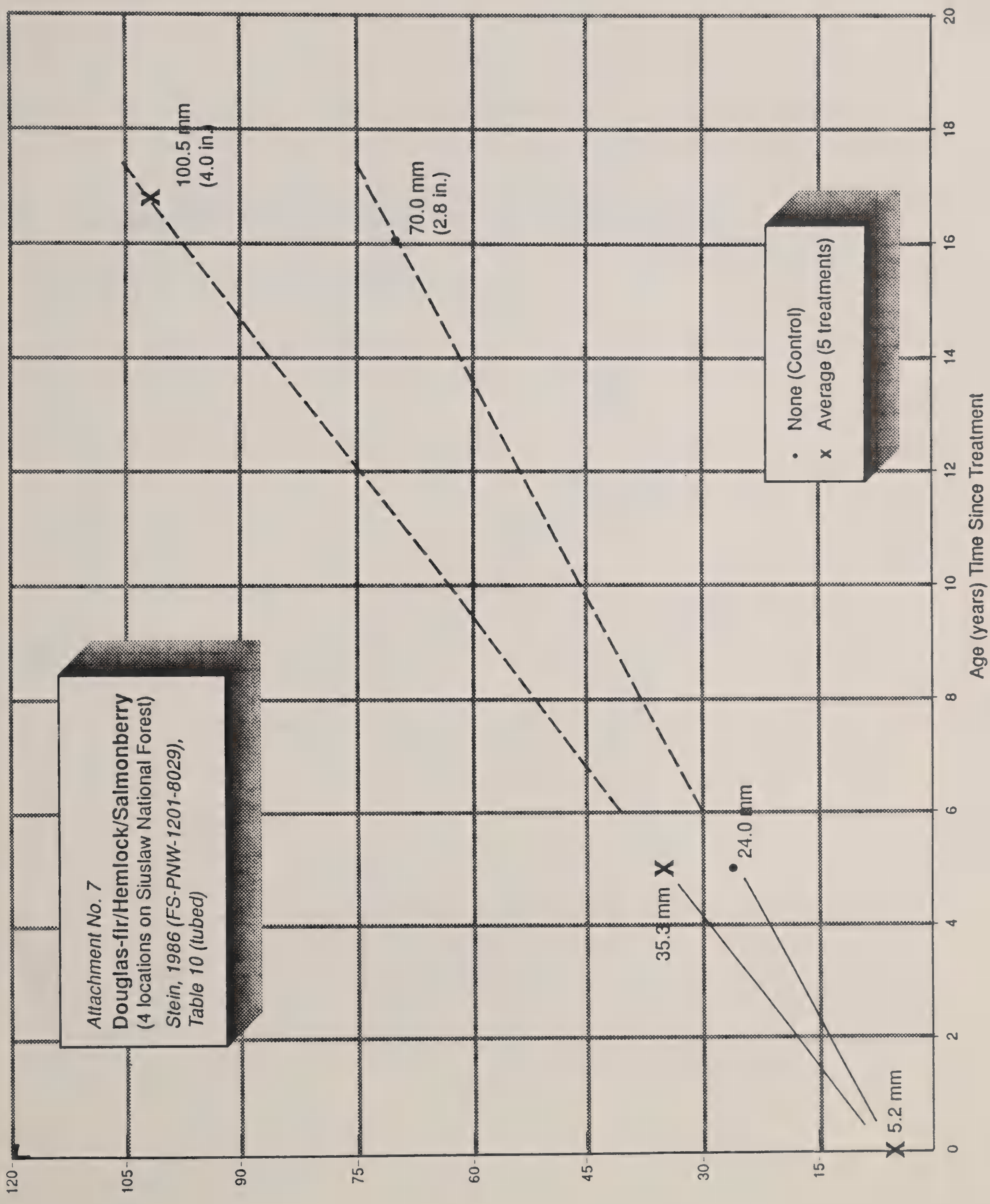

Attachment No. 2
Snowbrush ceanothus
Locations: Umpqua, 3 sites
Willamette, 1 site
Rogue River, 1 site
"clearcut 8 to 16 years earlier and occupied by dense cover of mature snowbrush"
Gratkowski, 1979, Table 3
Release: cut, stump spray
Height = 6 feet at time of release
Height = 4 feet at time of release
No Treatment
Height initially = 6 feet
Height initially = 4 feet
Average Diameter Growth
157 mm (6.18 in.)
105 mm (4.13 in.)
0
2
4
6
8
10
12
14
16
18
20
20
40
60
80
100
120
140
160


Attachment No. 3
Snowbrush ceanothus
Locations: Umpqua, 3 sites
Willamette, 1 site
Rogue River, 1 site
"clearcut 8 to 16 years earlier and occupied by dense cover of mature snowbrush"
Gratkowski, 1979, Figure 1 and Table 2
Release: cut, stump spray
Height = 6 feet at time of release
Height = 4 feet at time of release
No Treatment
Height initially = 6 feet
Height initially = 4 feet
Average Height Growth
39 ft.
(11.9 m)
25.7 ft
(7.8 m)
Age (years) Time Since Release
0
2
4
6
8
10
12
14
16
18
20
5
10
15
20
25
30
35
40


Attachment No. 4
Ponderosa Pine/Shrub/Herbaceous
(Cave Mountain Burn, Winema National Forest)
Crouch, 1979, Table 9
600 cm
(19.7 ft.)
352 cm
(11.5 ft.)
Control (No Treatment)
x Atrazine - 1st year, spring and fall;
2nd year, fall
Height (cm)
Age (years)


Attachment No. 5
Tanoak/Madrone
(6 locations on Siskiyou National Forest)
Owston and Davis, 1986, Figure 4
115 mm
(4.5 in.)
85.5 mm
(3.4 in.)
x Herbicide Treatment = Triclopyr or 2,4-D
(Average of 6 plantations)
• Control = untreated
(Average of 6 plantations)
Stump Diameter at 30 Centimeter Height (mm)
Age (years) Time Since Treatment
120
105
90
75
60
45
30
15
0
2
4
6
8
10
12
14
16
18
20


Attachment No. 6
Douglas-fir/Hemlock/Salmonberry
(4 locations on Siuslaw National Forest)
Stein, 1986 (FS-PNW-1201-8029), Table 5
810 cm
(26.57 ft.)
616 cm
(20.21 ft.)
• None (Control)
x Average (5 treatments)
Height (cm)
Age (years)
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
2
4
6
8
10
12
14
16
18
20

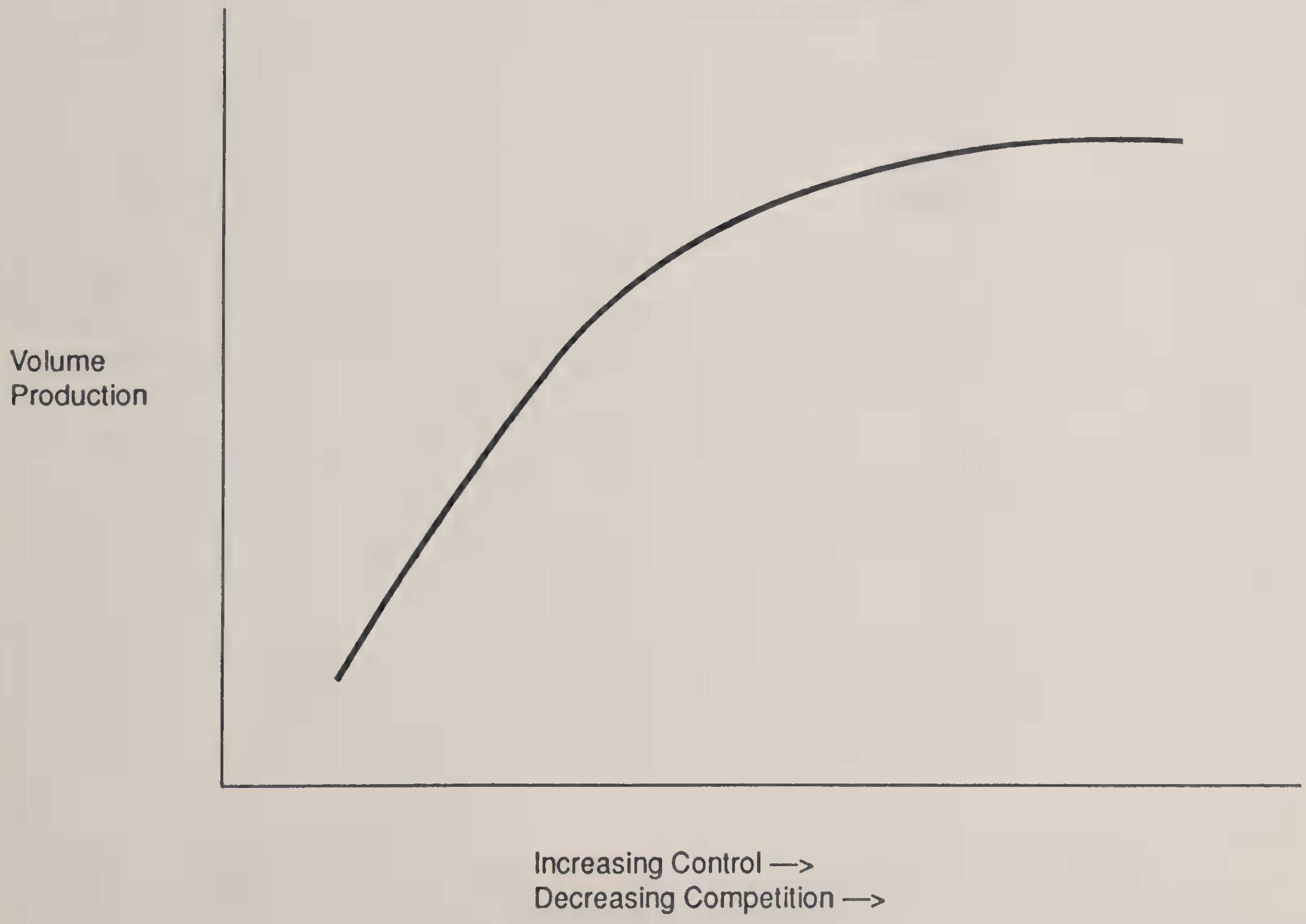

Attachment No. 7
Douglas-fir/Hemlock/Salmonberry
(4 locations on Siuslaw National Forest)
Stein, 1986 (FS-PNW-1201-8029),
Table 10 (tubed)
• None (Control)
x Average (5 treatments)
100.5 mm
(4.0 in.)
70.0 mm
(2.8 in.)
35.3 mm
24.0 mm
5.2 mm
Age (years) Time Since Treatment
0
2
4
6
8
10
12
14
16
18
20
15
30
45
60
75
90
105
120

Attachment No. 8

General Relationship Between Density and Volume Production

Attachment No. 9

General Form of the Relationship Between Volume Production and Competition



NOTE: Scale will change as species and site quality change.

Attachment No. 10

Full-yield Suitable Timberland Component
(Source: LMP DEIS, Table II-3a)

Forest	Acres (1,000's)	Forest Plan Component
Deschutes	952.1	Full Yield
Fremont	572.5	Full Yield
Gifford Pinchot	424.0	Full Yield
Malheur	821.5	91-100%
Mt. Hood	311.8	Full Yield
Mt. Baker-Snoqualmie	295.6	Full Yield
Ochoco	329.9	extrapolated from "E"
Okanogan	302.0	Full Yield
Olympic	371.4	Full Yield
Siskiyou	354.0	91-100%
Siuslaw	210.7	Full Yield
Umatilla	238.1	extrapolated from "F"
Umpqua	491.8	Full Yield
Colville	640.7	extrapolated from"intensive"
Willamette	733.1	95-100%
Winema	439.2	Full Yield
Wenatchee	252.7	91-100%
Wallowa-Whitman	151.2	91-100%
Rogue River	277.0	Full Yield
TOTAL	8,169.3	

Estimated Proportions of
Full-yield Timberlands (1,000 Acres)

Attachment No.11

Forest	Alder	Salmonberry	Ceanothus	Pine-herb	True fir	Tanoak	OTHER
			Vegetation Complex				
Deschutes	—	—	—	464.6	200.5	—	287.0
Fremont	—	—	171.8	143.1	171.8	—	85.8
Gifford Pinchot	21.2	—	21.2	—	84.8	—	296.8
Malheur	—	—	21.0	411.0	288.0	—	102.5
Mt.Hood	6.2	—	12.5	—	62.4	—	230.7
Mt.Baker-Snoqualmie	27.0	—	—	—	177.0	—	91.6
Ochoco	—	—	8.0	165.0	115.0	—	41.9
Okanogan	—	—	—	—	—	—	302.0
Olympic	111.4	37.1	—	—	—	—	222.9
Siskiyou	—	—	44.3	—	26.6	*106.2	141.0
Siuslaw	52.7	158.0	—	—	—	—	210.7
Umatilla	—	—	—	11.9	85.7	—	140.5
Umpqua	—	—	147.5	—	14.8	14.8	314.7
Colville	—	—	—	—	—	—	640.7
Willamette	18.3	—	219.9	—	73.3	—	421.6
Wenatchee	—	—	—	—	—	—	252.7
Wallowa-Whitman	—	—	4.0	75.6	50.5	—	21.1
Rogue River	—	—	152.4	—	69.3	8.3	47.0
Winema	—	—	110.0	165.0	55.0	—	109.2
TOTALS	236.8	195.1	912.6	1,436.2	1,474.7	169.3	3,960.4

*Tanoak component includes 76,000 acres with severe site competition—comprised of reforestation backlog (26,000acres) and hardwood conversion (40,000 acres) sites, plus existing, poorly stocked conifer stands (10,000acres).

Attachment No. 12 — Yield Simulation and Prescription Detail

A. Salmonberry complex

(1) **Model:** Stand Projection System

(2) **Managed Stand Input**

(a) Run id.: 5438

(b) Initial stand conditions:

Species	Dbh***	Height	TPA*	Age(BH)**
Douglas-fir	4.0	27	150	10
Douglas-fir	4.1	26	50	10
Western hemlock	4.0	27	100	10

(c) Site Index: 80 (base year 50).

(d) Rotation length: 80 years.

(e) Commercial thin: 1 (age 50).

*** TPA = trees per acre. ** BH = breast height. ***Dbh= diameter at breast height**

(3) **Managed Stand Output**

(a) Intermediate Yield: 4.5 thousand board feet/acre (mbf/ac.)

(b) Final Harvest (clearcut): 48.1 mbf/ac.

(c) Total Yield: 52.6 mbf/ac.

(4) **Unmanaged Stand Input**

(a) Run id: 1246

(b) Initial stand conditions:

Species	Dbh	Height	TPA*	Age(BH)**
Douglas-fir	2.8	20	150	10
Douglas-fir	2.9	21	50	10
Western hemlock	2.8	21	100	10
Red alder	2.5	20	30	10

(c) Site Index: 80.

(d) Rotation Length: 80 years.

*** TPA = trees per acre. ** BH = breast height.**

(5) **Unmanaged Stand Output**

(a) Total Yield: 41.4 mbf/ac.

B. Ceanothus spp. complex

(1) **Model:** Stand Projection System

(2) **Managed stand input**

(a) Run id: 5804

(b) Initial stand conditions:

Species	Dbh***	Height	TPA*	Age(BH)**
Douglas-fir	6.2	39	175	10
Douglas-fir	6.2	38	75	10
Redcedar	6.2	39	20	10
Western hemlock	6.1	38	30	10

(c) Site index: 100 (base year 50).

(d) Rotation length: 90 years.

(e) Commercial thin: 2 (ages 50, 70).

* TPA = trees per acre. ** BH = breast height. ***Dbh = diameter at breast height.

(3) **Managed Stand Output**

(a) Intermediate yield: 14.9 mbf/ac.

(b) Final harvest (clearcut): 71.6 mbf/ac.

(c) Total yield: 86.5 mbf/ac.

(4) **Unmanaged Stand Input**

(a) Run id: 1742

(b) Initial stand conditions:

Species	Dbh***	Height	TPA*	Age(BH)**
Douglas-fir	4.2	26	150	10
Redcedar	4.1	25	60	10
Western hemlock	3.9	25	60	10

(c) Site index: 100.

(d) Rotation length: 90 years.

* TPA = trees per acre. ** BH = breast height. *** Dbh = diameter at breast height.

(5) **Unmanaged Stand Output**

(a) Total yield: 53.2 mbf/ac.

C. Ponderosa pine - herbaceous complex

(1) **Model:** Prognosis (version 25)

(2) **Managed Stand Input**

(a) Run id: R6FPM*NORM

(b) Initial stand conditions: (stand table on file)

Species	QMD*	Height**	TPA***	Age (average)
Ponderosa pine	5.3	27	200	18

(c) Site index: 80 (base year 100).

(d) Rotation length: 100 years.

(e) Commercial thin: -0-

*Quadratic Mean Diameter. **Average. ***Trees per acre.

(3) **Managed Stand Output**

(a) Intermediate yield: none

(b) Final harvest (clearcut): 20.9 mbf/ac.

(4) **Unmanaged Stand Input**

(a) Run id: R6FPM*NOMGMT

(b) Initial stand conditions: (stand table on file)

Species	QMD*	height**	TPA***	Age (average)
Ponderosa pine	3.7	12	100	18

(c) Site index: 80

(d) Rotation Length: 90 years

*Quadratic Mean Diameter. **Average. ***Trees per acre.

(5) **Unmanaged Stand Output**

(a) Total yield: 10.9 mbf/ac.

D. Tanoak-Madrone Complex

(1) **Model:** DFSIM

(2) **Managed Stand Input**

(a) Run id: 2523

(b) Initial stand conditions:

Species	QMD*	Height**	TPA***	BA****	Age
Douglas-fir	7.3	50	300	87	27

(c) Site index: 80 (base year 50).

(d) Rotation Length: 90 years.

(e) Commercial thin: 1 (age 50)

*Quadratic Mean Diameter. **Average. ***Trees per acre. ****Basal area.

(3) **Managed Stand Output**

(a) Intermediate yield: 14.4 mbf/ac.

(b) Final Harvest (clearcut): 129.7 mbf/ac.

(c) Total Yield: 144.1 mbf/ac.

(4) **Unmanaged Stand Input**

(a) Run id: 2523

(b) Initial stand conditions:

Species	QMD*	Height**	TPA***	BA****	Age
Douglas-fir	7.4	50	165	49	40

(c) Site Index: 80.

(d) Rotation Length: 90 years.

*Quadratic Mean Diameter. **Average. ***Trees per acre. ****Basal area.

(5) **Unmanaged Stand Output**

(a) Total Yield: 48.7 mbf/ac.

E. True fir-shrub-herbaceous complex

(1) **Model:** Stand Projection System

(2) **Managed Stand Input**

(a) Run id: 3029

(b) Initial stand conditions:

Species	QMD*	Height**	TPA***	Age (BH)****
Grand fir	3.5	23	275	10
Douglas-fir	3.5	24	25	10
Lodgepole pine	4.0	26	20	10
Western larch	3.6	24	20	10
Grand fir	3.5	22	10	10

(c) Site Index: 60 (base year 50).

(d) Rotation Length: 120 years.

(e) Commercial thin: 3 (ages 50, 70, 90).

*Quadratic Mean Diameter. **Average ***Trees per acre. ****Age at breast height.

(3) **Managed Stand Output**

(a) Intermediate yield: 17.1 mbf/ac.

(b) Final Harvest (clearcut): 52.5 mbf/ac.

(c) Total yield: 69.6 mbf/ac.

(4) **Unmanaged Stand Input**

(a) Run id: 4119

(b) Initial stand conditions:

Species	QMD*	Height**	TPA***	Age (BH)****
Grand fir	3.5	23	60	10
Lodgepole pine	4.0	25	25	10
Douglas-fir	3.5	23	20	10
Western larch	3.4	22	20	10

(c) Site Index: 60.

(d) Rotation Length: 120 years.

*Quadratic Mean Diameter. **Average ***Trees per acre. ****Age at breast height.

(5) **Unmanaged Stand Output**

(a) Total yield: 31.0 mbf/ac.

Attachment 13

Sensitivity Testing of the Model

Douglas-fir was used to characterize the ceanothus analysis.

The effort to characterize long-term timber yields under the EIS alternatives does not lend itself to well defined confidence limits. A complex and heterogenous system must be grossly simplified in order to accommodate a relative shortage (in terms of amount, distribution, and time duration) of information and site-specific data. Fortunately, the study of plant interactions, species ecology, relative effectiveness of management techniques, and cost efficiency is now receiving emphasis from agency, industry, and university researchers.

This timber growth and yield analysis meets NEPA criteria: it is an assessment of consequences leading to a reasoned choice by the decision-maker. There is no effort to imply a high degree of precision simply because some of the estimates vary by only a few percentage points. Appendix A does, however, represent a rigorous analysis based on the best information and tools currently available.

A number of factors can necessarily lead to compounded statistical error terms:

1. The 105 papers and studies that were examined have a variety of objectives, designs, study parameters, timeframes, and statistical standards.
2. Estimates of vegetative complex areas have been made.
3. Certain data sets have been assumed to be the most representative of typical conditions.
4. Estimates of conditions representing severe levels of vegetative competition are used.
5. Expansion of any site-specific data to general observations involves uncertainty.
6. Modal productivity classes are defined as representative of some large landbases.
7. Short-term growth trends have been projected to a common stand age (see attachments 1-7).
8. Different yield models have been used to characterize the vegetation complexes.
9. Estimates of yield effects must be extrapolated for those timber

lands not characterized by any of the six vegetation types. *This variable is the principal reason for an increased predicted yield falldown under Alternative A (where herbicides are unavailable) in the Final EIS.*

Sensitivity analysis has therefore been used to establish some measure of reliability and accuracy for the alternative comparisons. The basic question asked in such an analysis is "how well does the model perform when parameters are changed?" Six variables have been examined. These are:

1. Site index
2. Intermediate thinning
3. Initial tree stocking levels
4. Species composition
5. Tree distribution
6. Proxy for the competing vegetation

A total of 43 simulations were made during the yield analysis. Ten of these were selected as the most accurate approximations of long-term (rotation length) yields. Simulations are process records on file at Forest Pest Management, Pacific Northwest Region, Portland, Oregon.

Three growth models were used in making yield projections:

Simulator	Vegetation Complex
1. Stand Projection System	Douglas-fir-hemlock/ salmonberry herbaceous
Stand Projection System	Douglas-fir-ponderosapine/ Ceanothus spp.
Stand Projection System	True fir-hemlock/shrub herbaceous
2. Prognosis (SORNEC)	Ponderosa pine/shrub herbaceous
3. DFSIM	Douglas-fir/tanoak-madrone

Estimates for the Douglas-fir/alder complex were developed from Turpin, Radican, and Knapp (1980). This decision-tree analysis by the Siuslaw National Forest used DFIT, an earlier version of the DFSIM model.

ORGANON (Hester et. al. 1987), a relatively new model with some impressive features and flexibility, was considered for the Douglas-fir/tanoak-madrone analysis. This model is based on growth relationships and data specific to forest types in southwest Oregon. In comparison, DFSIM has limited options (species mix, thinning re-

gimes, etc.) and volume equations that were developed from tree records taken over a much broader geographic area. This has the effect of exaggerating the actual per acre yields from stands within the tanoak-madrone belt (see attachment 12). The decision to use the DFSIM model was based on two factors:

1. DFSIM has been used by silviculturists and timber management planners since 1981. This has providedconsiderable operational and field verification of the model. The ORGANON model, by comparison, is relatively untested.

2. The relative difference between the paired yield simulations, rather than the absolute volumes, is used to predict timber yield effects. Precise estimations of timber growth and yields have already been developed for each Forest and timber strata in the managed yield ables used as input for the Forest land management planning process.

Results of the Sensitivity Testing

A. Site Index

Modal site productivity classes were used for individual vegetation complexes. Given the broad geographic distribution of the six complexes, it is felt that this will give a reasonable cross-section of Regional conditions.

Site index was tested using the Pacific Northwest and Inland Northwest Region tables in the Stand Projection System (SPS) model. True fir "managed" stands are displayed in the following runs. Site quality is varied, while all other parameters are essentially the same (stocking levels, species composition, tree distribution, thinning, crown ration, total age, etc.).

ID	Site Index (DF, 50 yr.)*	Merchantable Volume (MBF)**
0101	60	55.0
3215	60	54.8
1104	80	56.8
3130	80	56.4

*Douglas-fir site index. **MBF = thousand board feet.

Salmonberry-unmanaged stands were also examined, using site index as the principle variable in paired runs:

ID	Site Index (DF, 50 yr.)*	Merchantable Volume (MBF)**
2938	60	39.8
2256	80	42.2

*Douglas-fir site index. **MBF = thousand board feet.

A moderate error in site quality (plus or minus one class) does not appear to seriously distort board foot yields in the SPS model. Growth periods were 80 years and 120 years for the salmonberry and true fir comparisons, respectively. Variation in board foot yields are only in the three to six percent range for the examples shown.

B. Commercial Thinning.

Intermediate thinnings are scheduled in most of the managed stand simulations to display a prescription used for many regenerated stands in the Forest Planning process. This analysis is not an optimization exercise in the sense that numerous thinning regimes and schedules have been examined. The FORPLAN model used for harvest scheduling by each National Forest has been used effectively to look at a large number of thinning and management intensity options. For this reason, thinning prescriptions used in Appendix A tend to be on the conservative side (in terms of the number of entries, residual stand levels, and thinning methods).

The relative effect on total board foot volume due to thinning can be shown in several paired runs (all parameters other than intermediate thinning are essentially held constant).

ID	Identifier	*CT Age	(Volume, MBF)	Total Vol. (MBF)**
3029	True fir-Norm	50	(2.4)	—
		70	(6.6)	—
		90	(8.2)	69.6
3440	True fir-Norm.	-0-		56.4
0937	True fir-Norm.	-0-		55.7
5804	Cean-Norm.	50	(5.9)	—
		70	(8.9)	86.5
2015	Cean-Norm.	-0-		74.4
1246	Salmon-Norm.	50	(4.5)	52.6
1156	Salmon-Norm.	-0-		48.6

*Age at commercial thinning. **MBF = thousand board feet.

As would be expected, with the initial stocking levels used, density management and intermediate entries can have a large effect on the total board foot volumes realized. This is particularly true for vegetation types with relatively long rotation lengths. In the above SPS model examples, the effect on total yield ranges from 8 percent in the Salmonberry example (80 year rotation) to 20 percent in the true fir/herbaceous complex (120 year rotation). An error in the managed yield simulation, such as the absence of a intermediate harvest, will therefore result in a moderately large effect on total board foot yield.

The Ponderosa pine/herbaceous complex, modeled with PROGNOSIS, was the exception. In this case, relatively conservative thinning specifications (in terms of reserve stocking and crown classes removed) normally did not trigger a commercial thin. This appeared to be a function of the relatively low initial stocking—200 trees per acre (TPA)—and site productivity (SI 80-base year 100) for the complex.

C. Initial Tree Stocking

Initial stocking levels (at stand age 15 to 18) for managed stand simulations were normally held constant in order to provide a consistent frame of reference for the unmanaged stands. Acceptable stocking levels used for the complexes were:

Vegetation Complex	Trees per Acre
Douglas-fir/alder	260
Douglas-fir-hemlock/salmonberry/herbaceous	300
Ponderosa pine/grasses-herbaceous	200
Douglas-fir-ponderosa pine/Ceanothus spp./herbaceous	300
Douglas-fir/tanoak-madrone	300
True fir-hemlock/shrub/herbaceous	350

At these relatively low stand densities, an error in initial tree numbers could obviously translate into a large board foot volume change. An example can be seen in two paired simulations showing a ponderosa pine-herbaceous (no management) scheme with the Prognosis model.

ID	Stocking (TPA)*	Total Vol. (MBF)**
4438	50	6.7
0712	100	15.8

*TPA = trees per acre. **MBF = thousand board feet.

D. Species Composition

The true fir/herbaceous and Ceanothus spp./herbaceous complexes allowed a good deal of flexibility in species composition for the modeling of managed stands. Simulations used to display representative stands showed the following species mix:

Vegetation	Species and Trees Per Acre *							
Complex	ID	GF	DF	LP	WL	RC	WH	Total
True fir	3029	285	25	20	20	—	—	350
Ceanothus	5804	—	250	—	—	20	30	300

*Species, left to right: GF = grand fir; DF = Douglas-fir; LP = lodgepole pine; WL = western larch; RC = redcedar; WH = western hemlock.

Variations of these species mixes were used to test the effects on total volumes due to some species-specific coefficients used in equations for tree volume, diameter increment, tree taper, and so on.

Managed stands in the true fir simulations were predominantly grand fir, while Douglas-fir was used to characterize a typical stand in the Ceanothus analysis. Variable mixtures of other species were then used to test the model. For the true fir complex this included lodgepole

pine, Douglas-fir, and western larch. Western redcedar, western hemlock, and grand fir were used in the Ceanothus analysis.

In general, the amount and relative mix of the minor species had little effect on total board foot volumes. Examples can be seen in the following paired simulations:

Complex*	ID	No. of stems/species**	Total Vol.(MBF)***
TF-Managed	2958	245(GF) 75(DF) 20(WL) 10(LP)	58.6
TF-Managed	0101	300(GF) 20(DF) 20(WL) 10(LP)	55.0
TF-Managed	1104	255(GF) 50(DF) 20(WL) 25(LP)	56.8
TF-Managed	3215	300(GF) 25(DF) 15(WL) 10(LP)	54.8

*True fir "managed". **Species: GF = grand fir; DF = Douglas-fir; WL = western larch; LP = lodgepole pine. ***MBF = thousand board feet.

E. Tree Distribution

Stand clumpiness, or uniformity of tree spacing, can be used to model the effect due to nonstocked or understocked holes caused by seedling mortality. The SPS model allows an adjustment for "average portion of acre stocked with trees". Suggested values are: "high survival plantations" (.95) and "cutover natural stands" (.75). A value of .90 was used to characterize the "managed" condition for complexes modeled with SPS. This factor accurately reflects the level of density management employed during young tending in most managed stands. For "unmanaged" stands, the total board foot volumes were generally insensitive to changes in the "clumpiness" factor, apparently because of the low initial tree numbers. Examples were paired runs of the Ceanothus spp.-"no management" condition:

ID	Clump.	PercentTotal Volume (thousand board feet)
1742	.75	53.2
1551	.80	55.3
3428	.90	55.9

For this example in stands of moderate stocking levels (270 trees per acre), a 15 percent change in the "clumpiness" factor results only in approximately a 5 percent change in board foot yields at age 90.

F. Proxy for Understory Vegetation

An effort was made to model the effect of understory brush in pole-sized stands (age 15 to 18 years) through the use of seedlings of an undifferentialed, relatively short-lived species as a proxy. This was attempted in both the salmonberry and Ceanothus spp. analyses. Seedlings used were red alder (for the salmonberry analysis) and lodgepole pine (for the true fir analysis).

The outcome can be described briefly: **It didn't work.**

In nearly all cases the understory "brush" continued to grow with only limited mortality throughout the rotation length. This was true even in the long (120 year) rotation periods used for the true fir analysis. The effect tended to be a distorted total board foot volume, and no reliable or consistent way to correlate the degree of understory competition to crop tree growth. Examples of some "paired" simulations are:

Complex*	ID	Pole stock	Seed. stock	Total Vol. (MBF)
Salmon-No mgmt	4348	300	——	13.5
Salmon-No mgmt.	0945	300	100 (RA)***	12.0
Salmon-No mgmt.	3751	300	250 (RA)	10.6
True Fir-No mgmt.	5329	125	(LP)****	33.1
True Fir-No mgmt.	2131	125	200 (RA)	43.3

*Salmonberry "no management". **True fir "no management". ***RA = red alder. ****LP = lodgepole pine.

DISCUSSION

Of the six variables tested variations in initial stocking levels and commercial thinning regimes appear to have the strongest impact on total board foot yields.

The model appears to be relatively insensitive to moderate adjustments in site productivity, species composition, and clumpiness of tree distribution. An effort to proxy the effects of understory brush was unsuccessful.

Stocking Levels used to characterize a typical managed stand at age 15 to 18 years (following pre-commercial thinning) were fitted to timber type and site quality. Tree numbers used are representative of many operational prescriptions being used in the Region, and are compatible with the managed yield tables developed for the Forest land management plans.

Thinning schedules used in the "managed" stand simulations are also representative of the frequency, grade, and method of commercial thinning employed in operational prescriptions. As previously mentioned, the yield analysis in Appendix A is not an optimization exercise, but rather an attempt to present a cross-section of conditions within the geographic area represented by a vegetation complex. Stand densities used in the model will maintain basal area levels within the range in which total stand growth is relatively stable.

Appendix B

Economy Efficiency Analysis

B

Appendix B

The Economic Efficiency Analysis

Table of Contents

Table of Contents (continued)

The Economic Efficiency Analysis

Economic Efficiency Analysis

This section describes the costs and benefits. It also describes some of the concepts of economic efficiency analysis.

It discusses how the costs and benefits were derived, and how they were used in developing the Region's vegetation management program. In addition, this section deals with concerns about efficiency in our operations: essentially, the dollar value of our outputs and the dollar costs of our activities. Concerns about the effects on the local social and economic environments are covered in the Social and Economic Impact Analysis presented later in this appendix.

Because the efficiency analysis is linked to our budgets, we have also included budget concerns in this section of the document. We recognize that efficiency and budgetary concerns do not have any particular, unvarying relationship. Sometimes higher budgets mean lower levels of efficiency as when money is not wisely spent. Other times lower budgets may mean lower overall efficiency as in the case when "quick fixes" are employed for a temporary solution rather than spending more now on a good long-term solution.

Some Concepts Related to Efficiency Analysis

Priced Outputs (Benefits)

Priced outputs are those that can be exchanged in the market place. Their quantitative values are determined by actual market transactions or by estimation methods that produce prices comparable to those determined by market transactions.

Timber and forage are examples of commodities that are bought and sold in the market. Their values are determined through the interaction of buyers and sellers, based on supply and demand conditions in the market at the time of the transaction. Recreation visitor days (RVD's), on the other hand, are not normally exchanged via market transactions. Their market values are estimated by using some market transaction data in combination with various theoretical techniques.

Conceptually, these assigned values are consistent and comparable to those values which were actually derived via market transactions (Rosenthal and Brown 1985). Therefore, both assigned and market values are appropriate for calculating quantitative measures of efficiency such as Present Net Value (PNV). All benefits and costs are tracked in real terms (i.e., exclusive of inflationary effects).

Because timber and forage were the only dollar-quantified benefits projected to vary significantly by alternative, they are the only benefits included in the economic analysis.

Nonpriced Outputs

Nonpriced outputs are those for which there is no available market transaction evidence, and no reasonable basis for estimating a dollar value comparable to market values associated with the priced outputs.

In these cases, subjective nondollar values must be derived. These values are described qualitatively rather than quantitatively. They may be either positive or negative. In fact, what may be considered to be a benefit to one individual may represent a cost to someone else. Examples of nonpriced outputs include threatened and endangered species, natural and scientific areas, historical and anthropological sites, visual quality, and air quality.

Discounting

Analyses of investment options usually involve cash flows over different periods of time. Due to a number of factors, including the uses to which money can be applied, a dollar received today is worth more than a dollar received ten years from now. Discounting is a process whereby the dollar values of costs and benefits which occur at different periods are adjusted to a common time period so they can be compared.

In this analysis the common time period is the present, in which case the discounted value is referred to as a present value. The real discount rate used in the analysis is 4 percent. As a real discount rate, it is exclusive of the effects of inflation. The 4 percent real discount rate was also used in Forest planning. A 7-1/8 percent discount rate is used to show the sensitivity of the model to the selection of a particular real discount rate.

Present Net Value (PNV)

Present net value is the difference between the discounted value of all outputs or benefits for which monetary values or established prices are assigned and the total discounted dollar costs of managing the planning area. Forest Service Manual (FSM) 1971.2 defines PNV as "...the primary measure of economic efficiency for use in comparing alternatives."

The period of analysis used for this EIS is 100 years. This enables the model to reflect the changes that occur as the Forests are changed

to a managed condition. Costs and benefits beyond that point are insignificant due to discounting. Present net value calculations consider only the benefits and costs for which dollar values were assigned.

Priced benefits include timber and domestic livestock grazing. These benefits were compared with their related costs. PNV is an estimate of the respective alternative's excess of dollar-quantified benefits over its related dollar-quantified costs.

Opportunity Costs

Opportunity costs are defined as the value of the net benefit (of a resource) foregone, compared to the most economically efficient alternative use (FSM 1970.5).

In relation to the economic analysis performed for this analysis, opportunity costs represent the decrease in PNV which occurs when an alternative other than the one with the highest level of PNV is selected. Therefore, opportunity costs measure the net change in PNV for priced resource outputs and associated costs, and can be used to measure the net value sacrificed in order to produce the nonpriced benefits included in net public benefits.

Net Public Benefits (NPB)

Maximization of net public benefits is the goal of the analysis process. "Net public benefits" refers to the overall value to the nation of all outputs and positive effects (benefits) less all the associated inputs and negative effects (costs) whether they can be quantitatively valued or not. Net public benefits cannot be expressed numerically because the concept includes qualitatively-valued nonpriced outputs.

Net public benefits is the sum of the present net value of priced outputs plus the present net value of all nonpriced outputs.

Welfare Distribution Effects and Impacts

There is another level of effects which are also a concern. These are the welfare distribution effects influenced by the mix and level of outputs produced by the National Forests. They can be either positive or negative. These effects can be local, regional, or National in scope.

Some distributive effects, such as changes in consumer prices or taxpayer costs, have national level impacts. Others, such as induced jobs and income or payments to local governments, are more local or regional in nature. These concerns are more related to questions of equity (i.e., who pays and who benefits) rather than questions of

efficiency. They are not assessed in the context of the efficiency criteria associated with PNV. However, these positive and negative distributive effects need to be assessed as part of the net public benefit measures, since equity objectives often influence efficiency objectives and vice versa.

Parameters and Assumptions Used for Economic Efficiency Analyses

In order to calculate the Present Net Value (PNV) for each alternative, assumptions had to be made regarding discount rates, demand functions, a common reference point in time for dollar values, and real price and cost trends. This section summarizes these decisions and their resulting parameters.

This appendix is not intended to provide a blow-by-blow account as to how the analysis was performed. Rather it seeks to outline the process which is contained in the working papers.

Discount Rates

Discounting involves the application of a discount rate that represents the value of money over time when determining the present value of future costs and benefits. A 4 percent real discount rate was used to calculate the present net value for each alternative.

As a real discount rate, it excludes the effects of inflation. This is not an assumption that there will be no inflation. It is, rather, an assumption that the costs and benefits presented in the analysis will generally increase or decrease at the same rate as the rate of inflation. FSM 1971.21 states:

"Use a 4-percent real discount rate for evaluations of long-term investments and operations in land and resource management. Also, determine the sensitivity of alternatives to variations in the discount rate. At a minimum, use the rate used in the most recent Resources Program and Assessment to test sensitivity."

The 4 percent rate approximates the "real" return on corporate long-range investments above the rate of inflation (Row et al.,1981). The 4 percent rate was used to run FORPLAN during Forest planning. The 1985 Resource Planning Act (RPA) Program used a real discount rate of 7-1/8 percent. An analysis of the sensitivity of the Preferred Alternative to the discount rate was performed using the 7-1/8 percent discount rate as well. All costs and benefits are discounted from the midpoint of the decade in which they are expected to be incurred.

The discount rate is not equivalent to the federal government's cost of borrowing money (the interest rate paid for federal securities). It reflects rather the political, social, and economic needs and aspirations

of our citizens today and in the future. Questions such as "How much should those living today be willing to sacrifice for those living in the future?" and "How much should those living today be willing to sacrifice the earnings of future generations to achieve a desired end today?" are reflected in the discount rate.

In brief, the discount rate used in the analysis is not the same as the cost of borrowing money because:

- The cost of borrowing money includes a payment for inflation. The higher the rate of inflation envisioned by the lender, the higher the cost of borrowing. The economic analysis assumes that costs and benefits will generally change at the same rate as inflation, thus enabling us to work with a real discount rate.

- They are two different things. The cost of borrowing money reflects the market conditions in effect at the time the money is borrowed. The discount rate reflects our society's judgement as to whether society will be enhanced or reduced by the decision.

The Significance of the Discount Rate Used in the Analysis

The analysis process was not driven by the discount rate. The selection of activities and outputs would be the same even if a different discount rate had been selected. The model we used was not an "optimizing" model such as FORPLAN.

Rather, the alternatives were constructed to respond in different ways to the issues, concerns, and opportunities which surfaced during the scoping process. Each alternative had its own unique blend of emphases which were not triggered by the selection of a discount rate. The mix would have been the same had the discount varied up or down by five points. Changes greater than that would likely indicate a profound shift in the nation's political economy which would in turn shift the identification of issues, concerns, and opportunities.

Demand Functions and Real Price Trends

As specified by the Washington Office, USDA Forest Service, in a letter, Downward Sloping Demand Curves,[1] horizontal demand functions for timber and nontimber resources were used to analyze the alternatives for the DEIS. This was also consistent with the methods used in the ongoing Forest planning process.

[1] Gould, Norman E., Director of Timber Management, USDA Forest Service, Washington, D.C. 1981. Letter (1920) dated Feb. 3 to Regional Forester, Pacific Northwest Region. On file: Viegetation Management Project, USDA Forest Service, PO Box 3623, Portland, OR

Many factors can influence the demand for stumpage from any one Forest (Row et al. 1981). Some of these factors include trends in interest rates; the species and product mix; the use of wood for energy; forest products exports; the cost of Canadian lumber; the rate of technical improvement in wood processing; and the levels of harvests on other National Forests. Also to be considered are the full range of wood product substitutes and the full range of considerations dealing with their respective complementary goods and practices.

All these factors contain some degree of uncertainty. Neither the empirical nor the theoretical bases have been well enough developed to derive reasonable estimates of the demand functions for the resources offered at the Forest level. Evidence suggests that the elasticity in the portion of the timber demand curve for which the Forest can influence output levels is such that prices would be relatively insensitive to some "reasonable" range of Forest timber offerings.

In other words, it appears that the timber demand curve for the range of ouput levels analyzed during the development of alternatives is best depicted by a horizontal line. We assume that prices are insensitive to volumes offered. The assumption is admittedly strained in the case of Alternative C. The resulting figures for Alternative C should nevertheless provide a good basis for comparing it to the other alternatives. This comparison would be made more difficult with changes in unit values. The assumption is also consistent with that used in the most recent RPA program.

Real price trends were developed and used to represent the rate at which resource values will change over time as a result of anticipated supply and demand interactions in the market place. As specified by the Regional Office letter to Forest Supervisors, "Timber Price Trends, Values, and Costs",[2] a 1 percent per year increasing real price trend for stumpage was used for FORPLAN harvest scheduling analyses. This was applied for the first 50 years. No further change in the price trend was assumed for the remaining 50 years of the planning horizon.

Nominal stumpage prices (i.e., those which include the effects of inflation) are therefore increased during the next 50 years at a rate 1 percent greater than the rate of inflation. Thereafter they are assumed to change at a rate equal to the rate of inflation. Use of this assumption helps maintain consistency with the Forest Planning process currently underway in the Region and does not skew results. The projection spans a long period of time and thus does not avail itself of short-term

[2] Sirmon, Jeff M., Regional Forester, USDA Forest Service, Pacific Northwest Region. 1984. Letter (1920) to Forest Supervisors. On file: Vegetation Management Project, USDA Forest Service, PO Box 3623, Portland, OR

ground-truthing. One cannot gauge its accuracy by reviewing the results over a period of a few years.

It is important to note that the Region's Forests showed little sensitivity to changes in expected real price increases for stumpage values (Appendix B in each proposed Forest Plan DEIS) as shown in changes in ASQ (allowable sale quantity) or LTSYTC (long-term sustained yield timber capacity) or acres devoted to timber management. The sensitivity that was demonstrated was not universal even in terms of direction. For instance, using a 3 percent per annum compounded real price increase might increase first decade ASQ on one Forest and decrease it on another. However, one common theme that was displayed was that as the rate of real price increase grew, the incidence of more costly treatment techniques grew as well.

The overall analysis process was not driven solely by economics (i.e., by estimates of costs or benefits). Economics was one important factor in the analysis as were many others. The selection of activities and outputs in any given alternative would be the same even if a different real price increase had been used. The model we used was not an "optimizing" model such as FORPLAN.

Rather, the alternatives were constructed to respond in different ways to the issues, concerns, and opportunities which surfaced during the scoping process. Each alternative had its own unique blend of emphases which were not triggered by the selection of a particular real price increase projection. The mix would have been the same even if the rate of real price increase compounded annually had varied up or down by two points. Changes greater than that would likely indicate a profound shift in the nation's market equilibrium which would likely shift the identification of issues, concerns, and opportunities.

Consistent with Washington Office direction used in the ongoing Forest planning process, constant real prices were assumed for all other resources.

Real Cost Trends

Based on Washington Office direction used in the development of the Region's Forest Plans, constant real costs were assumed. That is, the costs of labor, fuels, materials, and all other factors of production involved with managing the Forest were assumed to change at a rate equal to the rate of inflation.

Real Dollar Adjustments

All costs and values used in the Forest planning process are expressed

in 1987 dollars. The Gross National Product (GNP) Implicit Price Deflator was used to convert historical nominal prices and costs to this common base. Because the Deflator had not yet been estimated for 1987 at the time of the analysis, the rate of increase for the period 1982 through 1986 was assumed to apply for 1987.

Externalized Costs and Benefits

Because of Forest Service management, benefits and costs accrue to others. These externalized costs and benefits are not tracked in the economic efficiency analysis. Where we were able to identify them as significant and varying among the vegetation management alternatives—and where they have been quantifiable—these costs and benefits have been documented in this EIS.

For instance, as a result of Forest Service management, certain jobs associated with livestock management exist. We identified those jobs (as well as personal income and payments to local governments) in the local economic impact analysis. Other externalized costs and benefits relate more directly to concerns of economic efficiency (e.g., the spread of noxious weeds or wildfire from public to private land).

Such concerns are real, but they have not been addressed quantitatively in the economic efficiency analysis. The decision-maker must address those and similar concerns qualitatively in arriving at a decision as to which alternative best maximizes Net Public Benefits.

Internal (to the decision) effects such as the effects on the allowable sale quantity are included in the analysis to the extent that they have been identified as being significantly different among the alternatives.

Cost Concerns and Unit Costs

During the formulation of alternatives, concern arose that the descriptions of Alternatives A, D, E, and F were not sufficient for an adequate understanding of their management implications and environmental consequences.

The specific question was whether commodity outputs or operating budgets would have precedence when estimating vegetation management program effects. (Forests operate within a budget and have expected levels of work activities to perform. These result in expected levels of commodity production, also called "outputs".)

Vegetation management methods vary in their economic efficiency: some cost more than others to achieve comparable results. Specialists on the National Forests could estimate the management implications of the alternatives in two ways—they could assume that

extra funds would be available to produce the expected outputs; or, if less efficient methods only were available, they could reduce the expected level of outputs when less efficient methods of vegetation management absorbed available funds.

Some increase in budgets could reasonably be expected if they were needed to achieve management objectives. But by the same token, the budget could not be viewed as being totally flexible in responding to Forest targets: the Forests could not expect a blank check.

Rather than making a decision at the Regional level (as to whether budget or outputs would take precedence), input on the question was requested from each of the Region's National Forests. Each Forest was asked to indicate how they would respond to Alternatives A, D, E, and F with both a budget-constraint emphasis and with an output-constraint emphasis. For example, each Forest constructed two separate estimates of costs for Alternative A:

- one attempting to meet the output levels specified in Alternative B, even in the face of substantial increases in costs; and
- one attempting to meet the output levels specified in Alternative B only insofar as would be possible with relatively minor increases in costs.

After reviewing the information from the Forests for these paired alternatives, it became clear that the overall purpose and theme of the original alternatives had more influence than either the budget or output emphases.

In general, cost differences between the paired alternatives were quite small. In the A and D pairings, 82 percent of the budget line items differed by less than 10 percent. Moreover, in A's pairings, more than half the Forests showed no difference between the paired alternatives at all. Those Forests literally saw no difference between an Alternative A with an output emphasis and an Alternative A with a budget emphasis.

Alternative E showed an even smaller difference between its two members, with 88 percent of the budget line items differing by less than 10 percent. In the case of the Alternative F pairings, 94 percent of the budget line items differed by less than 10 percent.

In some instances the Forests were able to use substitute methods which closely approximated the cost and the efficacy of the excluded methods. In other instances, the substitute measures were prohibitively expensive. In those cases the work was not done, and the effect

was noted as a reduced output level. Each alternative had a unique mixture of vegetation management practices.

The vegetation management team was faced with the prospect of analyzing two very similar alternatives for the themes present in Alternatives A, D, E, and F. That duplication would have meant a lot of extra work with very little possible gain in knowledge.

Accordingly, the interdisciplinary team agreed that team members responsible for compiling specific Forest information would review and validate their respective data. They were then to determine which data from the pairings best represented the levels of activities and costs that best fit the theme of each alternative.

Thus, in their present form, Alternatives A, D, E, and F represent the most reasonable and likely balance of costs and outputs that would be expected, given their respective themes.

Costs Used for Economic Efficiency Analyses

Costs Included in the Economic Analyses

This section describes the costs used to perform economic efficiency analysis for each of the alternatives considered during the development of the DEIS.

All Forest Service costs relevant to the question of vegetation management practices were included for the purposes of estimating budgets and calculating the present net value for each alternative. These costs were identified by their 1989 outyear budget codes. The outyear budget codes with their related descriptions were useful for identifying how different costs would be treated during the planning process. Because each Forest was solicited for cost and benefit data, the use of this common reference point was necessary to maintain comparability. All participants had the same definitions, thus, the same common denominator.

Costs tracked in the analysis reflect the costs of the "Five Steps" described in detail later in the EIS. The steps are:

1. Site analysis
2. Select strategy
3. Design project
4. Action
5. Monitoring

There are some activities on the Forests which have no real bearing on vegetation management practices. They are not significantly affected by how or whether vegetation management is practiced. During the course of the analysis it became apparent very early that there would be many Forest Service costs which would not be affected at all by this vegetation management analysis. They were not significantly affected by vegetation management processes. It was not necessary, therefore, to include those costs or their related benefits in the analysis.

However, it is important to remember that because the analysis did indicate that Forest outputs such as timber might be affected by the choice of alternative, that the costs and benefits which vary with timber sale offerings were included in the analysis.

The same situation applies to permitted livestock grazing. Additionally, some costs incurred by the public in their use of the National Forests were tracked because they could be affected by vegetation management practices.

Costs Not Included in the Economic Analyses

During the course of the analysis (and especially evident during the public comment phase of the analysis) were questions regarding cost inclusion. These included questions such as "Were the costs of nutrient replacement included in the analysis?" or "Was the cost of the Cleanup Fund included?"

In brief, almost all of these costs have been included in the analysis though not in the way most people would think. Costs associated with worker's compensation, worker's insurance, liability insurance, and licensing of materials and applicators, and so on are included in the analysis because these costs are included in the costs of the materials and the services when the government purchases them. They are not tracked as explicit line items, but they are nonetheless reflected in the bottom line cost of any activity.

Just as important are the implications of these questions. Many people have raised the possibility that there may be future "health alerts" or future causes for concern that ultimately result in claims, litigations, penalties, awards, and compensations. They want to know whether estimates of these possible costs have been developed and included in the analysis. Here again, the costs are normally included indirectly—as is done when manufacturers carry liability insurance to cover themselves in case of a defect in their manufacturing processes. The economic analysis has not included such costs (other than those included indirectly), because at this time, they are speculative.

If at some point in the future it was determined that routine exposure to gasoline, as occurs when filling a chainsaw or a vehicle, results in adverse human health effects or other loss, that newly established fact would have to be considered by management. Management has to consider the possibility of such future occurrences in arriving at a decision as to which alternative is to be implemented.

Others have expressed the view that certain off-Forest effects should be considered such as the losses to area communities that occur as a result of noxious weeds. Noxious weeds can reduce the carrying load of a pasture, can cripple or kill livestock, and can otherwise adversely affect the livelihoods of farmers and ranchers and their supporting communities. These are serious concerns. However, we were not able to accurately assess differences in such effects among the vegetation management alternatives. Large acreages of noxious weeds exist off National Forest lands.

Others have said that the cost of preparing this EIS should be identified as a cost of using herbicides, and that any extra costs associated with a particular tool should be charged against that tool. This is correct. If the use of any particular tool necessitates more advertising, more public meetings, more costs than another tool, then that tool should reflect those extra costs.

It would be inappropriate, however, to charge the costs of preparing this EIS against any single alternative, any group of alternatives, or any particular practice. This analysis is being conducted to determine the best way to manage competing and unwanted vegetation—not to justify the use of any particular tool or method.

If in the future an analysis is performed to determine whether a new tool or new method is appropriate for use, then the cost of that analysis would be properly chargeable to the introduction of that new tool or method. In the present context of developing this EIS however, the analysis is being conducted for all methods and all tools, and thus is the same regardless of the alternative ultimately selected.

"Nutrient replacement" and similar questions are handled in the economic analysis only insofar as they are reflected in timber yields. If a certain practice is expected to cause a falldown in timber yields, that reduction would show up as a reduction in benefits from timber production. In this as in other areas of the study, the economics reflect the physical analysis.

The guiding principle for identifying costs is contained in Forest Service Manual 1971.4:

"Limit identification of economic costs to only those costs in the production process up to the point of evaluation or to those costs that influence the values of outputs."

Fixed Costs

A cost was classified as being "fixed" if it was not expected to vary significantly over the range of alternatives considered. Such costs were largely eliminated from the analysis.

Variable Costs

All other costs are classified as being "variable". For instance, individual Forests have the ability to invest more or less money in vegetation management practices in response to the overall theme of an alternative. They also have the ability to change the levels of their outputs as the situation indicates.

Budget Considerations

During the analysis, cost data were solicited from every National Forest in the Pacific Northwest Region as well as from other sources. HERB, an electronic spreadsheet set containing all quantified costs and benefits, was used to track the figures.

Table B-1 lists the 1989 outyear budget codes used in the analysis to track dollar expenditures by individual line item. Other budget codes were addressed in aggregate to reflect changes which occured when vegetation management practices affected Forest outputs, such as timber and livestock grazing.

Table B-1

1989 Outyear Budget Costs Directly Affected By Vegetation Management Practices[1]

Code	Description
AT23	Trail Maintenance
CW222	Wildlife Habitat Nonstructural Improvements
CT222	Threatened and Endangered Species
	Nonstructural Habitat Improvement
DN222	Range Resource Nonstructural Improvement
DN24	Noxious Farm Weeds
ET241	Reforestation—Site Preparation
ET251	Timber Stand Improvement—Release and Weeding
ET252	Timber Stand Improvement—Precommercial Thinning
ET27	Genetic Tree Improvements
JL231	Landline Maintenance
LF23	Facility Maintenance
LT23	Road Maintenance
PF1	Fire Management Operations
PF12	Fire Suppression
PF24	Natural Fuels Improvements
PF25	Activity Fuels Improvements
	Activity Fuels Improvements—Purchaser
ET113 (NFAF)	Timber Resource Coordination
FA	Air Resource Activities

[1] Other budget line item costs are affected indirectly by vegetation management activities. For instance, an alternative that effectively reduced a Forest's allowable sale quantity (ASQ) would also reduce those costs and benefits associated with generating that ASQ. Those costs are not included in this table.

Table B-2 shows estimated budget impacts resulting from implementation of the various vegetation management alternatives. The information is presented so that the decision-maker, as well as other affected parties, can better see the effects on individual programs and line items. Presented in aggregate, significant changes might be masked. The table shows the effects on various forms of vegetation management.

As noted in the table, the costs shown reflect only the differences in the identified budget line items. There are also changes in such costs as timber sale preparation and timber sale administration when the allowable sale quantity is affected by an alternative. However,those changes are not reflected in this table.

Some relationships are evident in Table B-2. Genetic Tree Improvement costs generally reflect the degree of difficulty expected in managing vegetation. Range resource nonstructural improvements reflect in their own particular way the problems associated with trying to identify substitute methods that can be cost-effective.

In some instances the relationships among alternatives in terms of acres treated or dollars expended for treatment are not immediately obvious. An alternative may preclude the use of a particular tool which has no ready substitute. In such cases management may elect to do no work at all. This happened on some East-side Forests, when the use of fire to improve wildlife habitat was proscribed. Managers could identify no cost-effective tool that could replace fire and decided to allocate those dollar resources to improve wildlife habitat in different ways.

It is also true that many treatment practices or methods are not directly substitutable. For example, an acre typically treated once a year by one method may be replaced by twice-annual treatments using another method.

Table B-2

Direct Budget Effects Resulting from Vegetation Management[1]

(Average Annual Difference Over the Next Ten Years, 1987 Thousand Dollars)

Alternatives:	A	B	C	D	E	F	G	H
Budget Line Item								
Trail Maintenance	$ 593	$ 597	$ 261	$ 354	$ 586	$ 604	$ 617	$ 597
Wildlife Habitat Nonstructural Improvements	1,106	1,106	-0-	1,044	983	832	1,267	1,287
Threatened and Endangered Species, Nonstructural Habitat Improvement	58	58	-0-	58	58	58	58	58
Range Resource Nonstructural Improvement	205	389	21	254	389	389	467	399
Noxious Farm Weeds	323	357	-0-	271	281	314	783	357
Reforestation— Site Preparation	9,809	8,894	8	9,298	8,398	8,172	9,904	8,226
Timber Stand Improvement— Release & Weeding	7,309	4,409	-0-	4,747	5,698	5,018	6,526	4,419
Timber Stand Improvement— Pre-commercial Thinning [2]	12,962	12,982	751	7,897	12,643	22,973	13,628	12,513
Genetic Tree Improvements	1,374	606	58	1,050	1,224	1,177	1,182	537
Landline Maintenance	83	76	35	47	94	94	93	76
Facility Maintenance	361	163	254	139	31	307	156	163
Road Maintenance	3,878	2,278	2,539	2,288	2,192	2,115	2,629	2,278
Fire Management Operations	25,589	25,589	31,315	25,982	24,584	26,146	20,276	25,589
Fire Suppression [3]	15,542	15,542	15,542	15,542	15,542	15,542	15,542	15,542
Natural Fuels Improvements	1,569	1,569	-0-	1,337	5,491	1,523	1,235	1,966
Activity Fuels Improvements	21,480	21,833	1,493	14,206	13,615	14,271	20,584	20,887

Table B-2 (continued)

Direct Budget Effects Resulting from Vegetation Management[1]

(Average Annual Difference Over the Next Ten Years, 1987 Thousand Dollars)

Alternatives:	A	B	C	D	E	F	G	H
Budget Line Item								
Activity Fuels Improvements Purchaser [4]								
	22,026	23,112	4,127	15,186	17,352	18,036	23,006	20,921
Timber Resource Coordination [5]								
	2,176	2,204	1,639	2,102	2,072	2,170	2,262	2,204
Air Resource Activities	183	173	165	169	183	177	275	173

[1] Vegetation management is done as part of other goals or objectives, such as increasing timber production or providing for public safety along roadways. The costs shown on this sheet reflect only the direct costs associated with vegetation management in the work areas shown. Variation in vegetation management practices causes changes in other program work areas, and this causes changes in their associated costs. Those costs are not included in this table.

[2] Slash treatment component only.

[3] Fire Suppression costs are tracked after the fact: they are not included in budget proposals. They are shown in this table to provide the decision-maker with a more complete view.

[4] These are not budget costs. These are costs incurred by the timber purchaser. They result in lower bids on Forest stumpage.

[5] These are costs incurred by the Protection budget element in support of the Timber program.

Benefits Considered in Economic Efficiency

This section describes the benefits which were incorporated in the economic efficiency analyses for each alternative considered during the development of the EIS.

Resource outputs for which dollar values were assigned constitute the benefits included in the present net value calculations. Like the costs included in the analysis, only those benefits incurred during the 100-year planning horizon were incorporated in the PNV calculations. This period of analysis is adequate to capture all significant residual costs and benefits as shown in the following examples calculated using a 4 percent real discount rate.

A $100 annual payment for 100 years has a present value of $2,450. Extending the period to 150 years raises the present value to $2,493, an increase of some 1.8 percent over the 100-year value. Even a 25 percent difference in Present Net Value (PNV) becomes insignificant when applied to a total difference of 1.8 percent—less than one-half of one percent. The proportions would remain the same with the use of a different payment value.

No alternative under consideration would have its PNV ranking significantly affected by increasing the period of analysis to 150 years. The changes that do occur in allowable sale quantities after 100 years do not vary significantly by alternative. This is largely because indications are that the Forests will be managed in their aggregate to provide a nondeclining flow of timber and no Forest has proposed a protracted departure from the principle of nondeclining flow.

Future values are less heavily discounted with lower discount rates and more heavily discounted with higher discount rates. Keeping with the $100 annual payment for 100 years example used above, a 7-1/8 percent discount rate would yield a present value of $1402. Extending it to 150 years would increase its value to $1403. Using a very low discount rate of seven-eighths of a percent would yield a present value of $6,646 for 100 years, $8,335 for 150 years.

Benefits That Were Dollar-Quantified in This Analysis

The resources for which dollar values were estimated in this analysis are timber and domestic livestock grazing. FSM 1971.52 states:

"Determine values only for outputs that the Forest Servcie sells or potentially could sell, if the law or Forest Service policy permitted."

There are other benefits (such as recreation) that are normally dollar-quantified in an economic analysis, but were not in this analysis

because only timber and domestic livestock grazing were found to vary significantly among the alternatives. Values used for timber (stumpage) have been adjusted to exclude those sales that were sold at a premium but were never harvested. The values are representative of a six-year period so that figures would be representative of average market conditions rather than a particular point in time.

This is not to say that individuals will not be inconvenienced by vegetation management practices (including "no action"). Rather, it is to say that such practices normally are done during a short period of time; that they are timed so as to cause the least-possible inconvenience to recreationists; and that their effects per se are generally regarded as being transitory in nature.

Some recreation may be lost due to the form of vegetation management specified in the final preferred alternative, but some may be gained as well.

Because recreational use of the National Forests was not expected to be significantly affected by implemenation of any of the alternatives under consideration, it was not included in the analysis. Programs were included in the analysis insofar as their costs were affected by the alternatives under consideration.

The range outputs represent the amounts of forage to be grazed by domestic livestock and are measured in animal unit months (AUM's). AUM values represent permittee willingness-to-pay for grazing on the respective National Forests. The Forest Service entered into a cooperative agreement with the USDA Economic Research Service to develop livestock enterprise budgets for each National Forest. The Range Budget Approach was used for this analysis. Because Forest AUM's are not actually priced in a free competitive market, the calculated price is an estimate of market value. The Regional Office Direction Package of April 27, 1984 identifies the Forest-respective values.

Consideration of Nonquantified Costs and Benefits

The calculation of Present Net Value (PNV) provides efficiency data to use when comparing alternatives. Other factors also influence the decision-making process. In some cases the importance of nonpriced benefits, for which it is unrealistic to assign monetary values, can outweigh the advantages of producing a higher level of PNV.

It is very difficult to put a dollar value on something like visual quality, visibility, air quality, public health, ecosystem diversity, or the potential values from the future use of nonused species. Values can be

assigned for all these things. Everybody assigns them some sort of value in their own lives—in determining where they live, where they vacation, what kinds of food they eat, how they manage their own land, and so on. The difficulty comes when we attempt to standardize a value, i.e., to present a value representative of the feelings of the citizenry and their ability to pay for it.

Rather than try to dollar-value all these concerns—many of which are not even easily counted in physical terms—we have left their consideration to the decision-maker. 40 CFR 1502.23 states:

"...For purposes of complying with the [National Environmental Policy] Act, the weighing of the merits and drawbacks of the various alternatives need not be displayed in a monetary cost-benefit analysis and should not be when there are important qualitative considerations...."

Many people are concerned that their aspirations for the Forests are not considered because they have not been dollar-quantified and included in the analysis. The concern is unfounded. It's exceedingly rare to see a decision made to select the alternative which has the highest PNV. Decision-makers do consider those things which have not been dollar-quantified, and they loom large in the decision-making process.

The importance of the need to consider these subjectively-valued benefits in Forest management decision-making is addressed in the NFMA Regulations which charge the Forest Service with identifying the alternative which comes nearest to maximizing net public benefits (36 CFR 219.12(F)).

Net public benefits (NPB) represent the overall value to the nation of all outputs and positive effects (benefits) less all associated inputs and negative effects (costs), whether they can be quantitatively valued or not (36 CFR 219.3).

Net public benefits include both priced and nonpriced resource outputs, less all costs associated with management. As stated earlier, all priced outputs and costs associated with vegetation management on the National Forests are included in the calculation of PNV. To this, the net subjective values of the nonpriced outputs must be included in order to arrive at the overall NPB of an alternative. Some of the more important nonpriced concerns addressed during the planning process included the following:

Public Health

Public Participation

Social and Economic Effects

Environmental Effects

Effectiveness of Techniques

Interagency Coordination

These are all affected by Forest vegetation management. They are all related to one or more issues and concerns which were identified at the outset of the planning process.

Nonpriced Outputs Considered

The nonpriced outputs considered during the development and evaluation of alternatives are discussed below. While the quantitative dollar values of each are not determined, they can generally be evaluated by examining such quantitative indicators as acres of treatment.

- Public Health: Health issues related to the management of vegetation have been a major focus during the past decade and continue to be a concern. Much attention centered on the safety of herbicides used in vegetation control. We received many comments on the need to evaluate human health impacts. Management is attuned to these concerns just as they are to the numerous other concerns frequently voiced concerning management of the National Forests. Public perception of health risks are very real concerns, whether the scientific literature supports them or not.

- Public Participation: The extent to which affected parties feel they have a say in the decision-making process affects the degree to which they will participate in the process. It also affects their feelings of independence and self-control.

- Social and Economic Effects: Vegetation management activities have both direct and indirect effects on employment, personal income, payments to local governments, and the overall quality of community life. Many of these effects have been quantified, but their weight in the overall consideration of Net Public Benefits is left to the decision-maker.

- Environmental Effects: There is widespread concern about the physical and biological effects of using vegetation management techniques. The decision-maker will need to consider the complex

physical and biological linkages; the sensitivity of ecosystems; and the direct, indirect, long-term, and cumulative effects.

- Effectiveness of Techniques: Vegetation management techniques vary in their effectiveness depending on site-specific conditions. This variability in effectiveness is better documented for some practices than for others.

- Interagency Coordination: Agencies at all levels of government have a shared interest in resource management through vegetation manipulation. Many will be directly affected by decisions made in the EIS, others indirectly. Many agencies reminded us of cooperative agreements, administrative or cost impacts, and shared legal responsibilities or liabilities. All are factors for the decision-maker to consider.

How the Efficiency Analysis Was Done

The task was to estimate the relative efficiencies of the different vegetation management alternatives to come up with an understandable bottom line number that reflected how the Region's nineteen Forests would respond to the different themes of the alternatives. The analysis had to reflect the very real differences that exist on the Region's Forests and yet be comparable among the Forests.

In order to establish comparability among the Forests, we used their projected Fiscal Year (FY) 1989 outyear budgets. These budgets shared a common set of definitions, a common reference point in time, and were the most current information available. They had been developed with a common understanding relative to vegetation management activities—namely, that all tools and practices would be available. They were also the embodiment of the Forests' respective Proposed Forest Plans.

In itself, that was nothing unusual. The Forests have been projecting outyear budgets based on their Proposed Forest Plans for many years. A budget must be based on some anticipated course of action, and a Proposed Forest Plan constitutes an acceptable future scenario. The use of a Proposed Forest Plan for outyear budgeting or other analytical purposes does not necessarily predispose the decision-maker to select that alternative. Detailed budget analysis may make the Proposed Forest Plan look better or worse in the decision-maker's eyes.

The FY 1989 outyear budget thus provided the starting point for the analysis. It contained estimated costs for individual budget line items and associated activities and outputs. It became the reference point. It represented a future scenario that might occur if all vegetation management tools and practices were available.

It was then necessary to develop estimates of the effects that would occur if vegetation management practices were to change, i.e., to show how costs and benefits would be affected. After consulting with specialists on the vegetation management team, the Regional Office staff, and others, it became apparent there was simply too much diversity in the Region's Forests for the team to handle the entire question by itself.

The analysts responsible for the various analyses decided in conjunction with management that the best course was to consult with each Forest staff as to how they would respond—line item by line item—to changes in the ways in which competing and unwanted vegetation is managed.

That information was then solicited from each Forest for each budget line item. The Forests were free, within the normal constraints of time and personnel, to develop their responses. The amount of effort required on the part of individual Forests varied considerably.

The vegetation management team analysts then worked with the feedback from each Forest, reviewing the estimates, comparing them with the estimates of other Forests, evaluating them, and consulting with Regional Office staff and others. From this work, the analysts developed a synthesis. Sometimes a Forest's input was used as it was provided by the Forest. Other times it was modified based on consultations with the Forest, with the Regional Office, with other experts, and based on the team analysts' understanding of the problem.

An important part of this process was the development of estimates as to how much the respective Forests' allowable sale quantities (ASQ's) would be affected by the alternatives. In fact, this became the biggest part of the efficiency analysis. Changes in ASQ caused by changes in Vegetation Management alternatives were far and away the principal driver in the economic analysis. The Forests and the vegetation management team analysts were aided in this review of the potential ASQ effects by the large amount of analysis done at the Forest level in developing the Forest Plans.

FORPLAN estimates of ASQ effects were particularly helpful. On the average, each Forest had made hundreds of FORPLAN runs. (The norm is probably better represented as being in the area of hundreds of FORPLAN runs.) These runs reflect the answers to all manner of "what if" questions, including concerns about increasing and decreasing costs and benefits. The Forests were encouraged to use this information in developing their estimates of ASQ effects, and the vegetation management team used the analytical summaries of these analy-

ses as contained in the Proposed Forest Plan DEIS's and their Appendices.

The ASQ effect is so important because 1) it costs a great deal of money to prepare and administer timber sales, and 2) these sales bring in a great deal of money. Small changes in the allowable sale quantities (ASQ) yield effects much greater than those associated with changing vegetation management practices.

Social and Economic Impact Analysis

Social and Economic Overview

To assess the current economic conditions and to estimate potential changes, an Area of Influence was determined. This is the geographic area wherein the majority of Forest products are first used and wherein public concern is concentrated. Area population is shown in Table B-3.

Table B-3

Area Population Over Time

	1940	1950	1960	1970	1980	1986
Oregon	1,090,000	1,521,000	1,769,000	2,091,000	2,633,000	2,660,000
Washington	1,736,000	2,379,000	2,853,000	3,409,000	4,130,000	4,420,000
Total	2,826,000	3,900,000	4,622,000	5,500,000	6,763,000	7,080,000

Source of 1940-1980 data: the decennial census. 1986 Oregon data calculated from Table 3 of Population Estimates of Oregon, Counties and Cities, July 1, 1986, published by the Center of Population Research and Census, School of Urban and Public Affairs, Portland State University. 1986 Washington data calculated from Table 9 of 1986 Population Trends for Washington State, August, 1986, published by the Office of Financial Management of the State of Washington.

Determination of Social Effects

Social effects are changes in communities, peoples' beliefs, and their ways of life. Specifically, the social effects of the vegetation management alternatives are the different social conditions they cause.

Estimation of social effects is a two-step process. First, the conditions that are expected under the current management direction over the next 10 years are estimated. Then the factors that would change because of different management direction (alternatives) are noted and

compared to the current management direction (or "baseline") conditions.

The following categories encompass the significant social effects of the alternatives developed for vegetation management. The social effects for the Region are reported together and special note made where the effects on any subarea are substantially different.

- Lifestyle and Job Dependence: Effects are indicated by significant changes from baseline conditions in the patterns of work, leisure, and other activities. Dimensions include the availability and characteristics of jobs, recreational activities, aesthetic and amenity ties to the National Forests, and the gathering and use of food and fuel from the National Forests.

- Beliefs and Perceptions: Significant effects are indicated by outputs and practices at odds with the understandings and emotional values people have for the Forest.

  Dimensions include concerns that familiar places will be changed; that full use of Forest commodities will be restricted; and that disliked or unsound practices will occur. People have concerns for visual qualities; for the Forests as a natural or managed ecosystem; for environmental qualities; and for historical and cultural sites and characteristics.

- Sense of Control/Sense of Self-sufficiency: These effects are indicated by changes from the baseline conditions in the degree of control that affected groups perceive they have over the National Forests compared to outside forces (e.g., government, interest groups, or industries). It also reflects the affected groups' sense that they can contribute to their subsistence needs (food, fuel, shelter) by their own direct knowledge and effort. Dimensions include concerns about government restrictions on uses and practices, and changes caused by special interest groups.

  People who gain food or fuel directly from the National Forests are concerned about reduced access or supply. Because local area inhabitants live so close to the National Forests, their sense of control or self-sufficiency is more profoundly impacted by National Forest actions than are others. Next in order of significance would be the recreationists from outside the area who have, in many cases, been returning to the area for years. This latter group and other recreationists would suffer a loss in their sense of control or self-sufficiency if their existing recreational enjoyment were to be reduced.

Categories of Social Effects Considered, But Not in Detail for Each Alternative

In addition to the three main categories of social effects, the effects of the alternatives on population change and the effects on land use and ownership were examined.

- Population Change: Selection of a vegetation management alternative may affect the level of economic activity in the Pacific Northwest Region. This may ultimately affect migration and population. However, many short-term changes can be accommodated without changes in population.

  In recent years, migration has been responsive both to employment opportunities and to a variety of amenity and lifestyle factors so that a precise population projection tied to the vegetation management alternatives is not presented. However, employment and population are generally recognized as being directly related.

- Land Ownership and Use Changes: Land exchanges will be primarily with private parties, corporations, or other government agencies which normally use the land for purposes similar to current National Forest management. Land for development is not significantly affected, either directly or indirectly, by the alternatives presented.

Use of the IMPLAN Computer Model To Estimate Effects on Jobs and Personal Income in the Local Area

Use of IMPLAN in Estimating Vegetation Management Effects

Effects on the local economy from timber outputs, permitted livestock grazing, and Forest budgets were developed using IMPLAN. These three "effect groups" were used because they vary significantly among the alternatives and because they were thought to have the potential for significant effects themselves. The IMPLAN model was run separately for Oregon and Washington. Table B-4, Jobs Coefficients, shows the response coefficients generated. The process involved estimating the dollar values that would be injected into the local economies with a change in timber offerings, permitted livestock use, or Forest budget levels.

Table B-4

Jobs Coefficients

Relationship of Jobs to National Forest Effects

	Oregon	Washington	Total
Permitted Livestock Grazing (Per Thousand Animal Unit Months (AUMs))			
Direct	0.12	0.12	0.12
Indirect	0.32	0.28	0.30
Induced	0.22	0.21	0.22
Total	0.66	0.61	0.64
Forest Budgets (Per Million Dollars)			
Direct	$16.26	$12.53	$14.40
Indirect	5.63	4.15	2.89
Induced	19.97	17.28	18.63
Total	41.86	33.96	37.91
Timber Offerings: Per Million Board Feet (MMBF)			
Direct	4.71	4.53	4.62
Indirect	4.42	4.30	4.36
Induced	7.79	8.46	8.13
Total	16.92	17.29	17.11

"Direct jobs" (and personal income) are in those sectors of the economy which realize the increase in sales. For instance, money is injected into the local economy in the case of timber sale offerings when the timber has been manufactured into its final form and sold. Direct jobs are those in manufacturing firms that make those sales.

"Indirect jobs" (and personal income) are those associated with firms that supply the wood processing sector such as logging contractors. The term "induced" refers to the job and income effects generated when those employed directly or indirectly then respend their money in the local economy. Direct and indirect effects are sometimes lumped together under a nondirect heading.

"Jobs" includes full- and part-time positions, temporary and permanent positions without discrimination. Many people are uncomfortable with this usage. They feel more comfortable with the use of some kind of full-time equivalency. Such an estimate can be provided by dividing the Personal Income coefficient by a representative annual wage. For instance, Table B-5 shows a total personal income coefficient of $.4328 million per million board feet—that's some $433,000 in wages and salaries per million board feet. To get an annual equivalent of $25,000 per year jobs, divide the $433,000 by $25,000. That would provide a rough equivalent in terms of full-time jobs.

Table B-5

Personal Income Coefficients[1]

(In Both 1977 Million Dollars & 1987 Million Dollars)

	Oregon	Washington	Total
Permitted Livestock Grazing (Per Thousand Animal Unit Months)			
Direct	$ .0005— .0009	$ .0005— .0009	$ .0005— .0009
Indirect	0033—.0058	.0030—.0053	.0032—.0056
Induced	.0025—.0044	.0025—.0044	.0025—.0044
Total	.0063—.0111	.0060—.0106	.0062—.0109
Forest Budgets (Per Million Dollars)			
Direct	$ .2053— .3624	$ .1574— .2778	$ .1814— .3202
Indirect	.0813—.1435	.0623—.1100	.0718—.1267
Induced	.2252—.3975	.2046—.3611	.2148—.3791
Total	.5118—.9033	.4243—.7489	.4681—.8262
Timber Offerings (Per million board feet (MMBF))			
Direct	$ .0824— .1454	$ .0847— .1495	$ .0836— .1476
Indirect	.0661—.1167	.0691—.1220	.0676—.1193
Induced	.0878—.1550	.1002—.1769	.0940—.1659
Total	.2363—.4171	.2540—.4483	.2452—.4328

[1] Figures generated by IMPLAN are in 1977 terms. To provide some idea as to how these prior year dollars would be expressed in today's terms, the 1977 figures were converted to 1987 figures using the Gross National Product Implicit Price Deflator.

"Direct jobs" (and personal income) are those associated with those sectors of the economy which realize the increase in sales. For instance, money is injected into the local economy in the case of timber sale offerings when the timber has been manufactured into its final form and sold. Direct personal income effects are those in manufacturing firms that make those sales.

"Indirect jobs" (and personal income) are those associated with firms that supply the wood processing sector such as logging contractors. The term "induced" refers to the job and income effects generated when those employed directly or indirectly then respend their money in the local economy.

"Personal Income" is not differentiated based on the source of the income.

There is variation in the labor and income components of the different methods of vegetation management. Manual treatment is more labor intensive than is the aerial application of chemicals.

In relation to total area Personal Income, National Forest-related personal income associated with vegetation management practices accounts for two percent of the total. Table B-6 summarizes the findings.

Table B-6

Forest-Related Personal Income in Relation to Area Totals

(Includes Only Those Programs Directly Affected by Vegetation Management)

	Oregon[1]	Washington[1]	Total[1]	Nat'l. Forests[2]
Million Dollars	$24,634	$42,118	$66,752	$1,274
Percentage of Total	37%	63%	100%	2%

1 Source for "Oregon," "Washington," and "Total" data is the Statistical Abstract of the United States, 1984 published by the U.S. Government Printing Office. Figures shown are for 1980.

2 National Forest estimates were calculated using a likely future scenario for Forest outputs and the IMPLAN coefficients shown in this appendix. It is important to remember that these figures exclude Forest employment associated with those outputs and activities with no significant relationship to vegetation management. They do, however, include all personal income associated with National Forest timber offerings, the permitted livestock grazing program, and Forest budgets. Forest figures are in 1977 dollars. Converting them to 1980 dollars would not change the two percent (rounded) figure.

Uncertainty in the Analysis

It is important to "...recognize that all unit values, and especially future values, are only approximations of the worth of the outputs, and are used to assist in placing relative priorities on plan or project alternatives, along with numerous other criteria." (FSM 1971.63—1.d., since superceded.)

Use of Averages

Nearly all data used in this analysis are average (arithmetic mean) values or are derived from averages. This use of averages to represent the National Forests is necessary because it would be impracticable to physically collect precise data on every acre.

Even if it were possible, each acre would be represented as an average situation. The use of averages means that some areas of the National Forests will have their costs or benefits or other characteristics substantially overstated or understated. Thus a decision to manage or not manage vegetation on a certain land type based on averages is not always correct. That is one reason why we are required to do project level analysis.

A ludicrous example of using averages would be the use of Region-wide averages for stumpage values. Such gross averaging would mask the very differences which the analysis is supposed to identify and consider.

To minimize this problem, information was collected from each of the Pacific Northwest Region's nineteen National Forests. This allowed the analysts to recognize and maintain the identity of those characteristics which are relevant to the decision-making process. The detail of this stratification approaches the limits of practicality for assembling and analyzing data at the Regional level.

Projections

Another area of uncertainty is that which arises in making projections into the future. This includes such things as the growth rates of timber and its projected value. By definition all projections into the future are extrapolations beyond known data points. The farther the projection is extended, the greater the uncertainty.

As far as efficiency considerations, budget conerns, and local economic impacts are concerned, our review showed a relatively low degree of sensitivity to the costs of vegetation management. That does not mean that the Forest Service is not concerned about the costs of vegetation management. Rather, it reflects the fact that vegetation management costs are relatively small compared to other costs involved in Forest Service management.

Increases in vegetation management unit costs which appear huge relative to vegetation management costs still leave the total cost of vegetation management quite small relative to the overall level of costs associated with the relevant output.

Historical Data

National Forest historical data is not free from uncertainty. The Management Attainment Reporting Systems (MARS), for instance, is used to record Forest achievements. Live Timber Offerings are included in MARS Code 17.1 and Mortality Offerings in 17.2.

Historically, some of the National Forests have reported merchantable endemic tree mortality as Live Timber Offerings. This is understandable because the material can be processed like live sawtimber. Strictly speaking, however, the material should be included in mortality offerings. This causes concern when comparing future empiric yields (which exclude all mortality volume, no matter how recent the mortality or how valuable the timber) with historical Live Timber Offerings which include merchantable endemic mortality volume. The amount of mortality volume included is not known, nor can it be retrieved from Forest records which were not set up to track this data for future recall.

Estimates of jobs, personal income, and payments to local governments also have a high degree of uncertainty. All three rely on the physical data used to generate timber yields and, therefore, share in all the uncertainty implicit in those estimates. Beyond those concerns, jobs and personal income estimates are necessarily approximate in that they rely on the IMPLAN Model which uses 1972 average technological coefficients.

Many improvements have been made in productivity in the timber industry and in other industries since the technological coefficients were developed. The September 1987 issue of Timber/West carried a news item on page 2 identifying a reduction in employment per million board feet from a 1979 level of 4.5 employees to a 1986 level of 2.79. Allowing for the normal differences in definitions and assumptions, the 1979 estimate is quite close to the 4.62 figure generated by IMPLAN, as shown in Table B-4.

It takes a lot less labor to produce lumber than it used to—a phenomenon that has been tracked for hundreds of years in various industries. Certainly, updating the coefficients is in order, and that process is underway. Payments to local governments are primarily a function of Forest stumpage values—values which can be modified through changes in the appraisal process, the period allowed a contractor for harvesting the timber, legislative changes, etc.

Physical Data and Its Relation to Economics

Probably the largest single area of uncertainty in the analysis is the association that exists between long-term sustained yield timber capacity (LTSYTC) and the allowable sale quantity (ASQ) effects in the early decades.

Basically, the changes in vegetation management being considered here involve standing timber inventory only to a limited extent. Those stands are established and either already are (or will be in the future) ready for commercial harvesting, regardless of which alternative is selected for vegetation management. It is those stands that the Forest Service is relying on to make up the overwhelming bulk of its sale program in the coming early decades.

To some extent, these existing stands could be affected by the threat of wildfire if an alternative were to be selected which so restricted slash treatment as to significantly increase the likelihood of losses to wildfire. In some alternatives that threat is a very real one, but in general expected losses are not anticipated to vary greatly among the alternatives. Any significant losses in existing ready-to-

harvest timber inventory could reasonably be expected to translate into losses in the allowable sale quantity in the first decades.

Of far greater concern is the question of how future timber yields will be affected on those lands whose reforestation and release has been detrimentally affected. Here, though, the relationship between long-term sustained yield timber capacity and the allowable sale quantity in the early decades is not determinate.

It depends on the relationship that exists on each Forest between its established timber inventory and allowable sale quantity schedule. A Forest which expects to see its allowable sale quantity stairstep upward in future decades as more productive stands replace slow-growing older stands could likely suffer a significant falldown in yields on those future stands without seeing a decrease in allowable sale quantity in the early decades.

For such a Forest, losses in stocking level or slower growth due to the presence of competing vegetation might simply mean that in the distant future, its harvest level might not increase as much as it otherwise could have.

Other Forests however, are operating very near to the level of their long-term sustained yield timber capacity. That is, their allowable sale quantity is very near to their long-term sustained yield timber capacity. For those Forests, a falldown in future yields might well translate directly and proportionately into falldowns in the allowable sale quantity even in the early decades.

Another instance is the case of those Forests which are anticipating departing from the policy of nondeclining even flow. Those Forests may see disproportionately large falldowns in their early decade allowable sale quantities resulting from losses on their future stands.

Many people treat the entire question of the long-term effects of vegetation management with considerable skepticism. They anticipate that current-day "disruption of ecological relationships through the artificial manipulation of vegetation" will precipitate costly future corrections. Certainly, history provides numerous instances of this. At this point in time, however, it would not be feasible to attempt to quantify these speculative concerns in the economic analysis.

Adding further to the level of uncertainty is the continuing swirl of social, economic, and political aspirations of the nation which itself continues to change.

Sensitivity Analysis

The single feature most responsible for the outcome of the economic efficiency analysis is the set of estimates regarding the effects of the alternatives on the Forests' allowable sale quantities (ASQ's). This is because the costs of vegetation management are themselves quite small relative to the overall costs and benefits associated with timber management.

To gauge the full extent of that dependence, a sensitivity test was conducted to see exactly how much the model was driven by ASQ effects.

If disproportionately large changes occur from relatively small changes in an input datum, the model is said to be sensitive to that bit of input. If on the other hand, large changes could be made in that input with little or no change in the model's output, then we would deduce that the model was relatively insensitive to that input. Sensitivity tests thus can be used to test just how the analysis responds to changes in input data.

Table B-7 shows the effect on various economic criteria if we were to assume that the alternatives could be put into place with no effect on the allowable sale quantity. This scenario holds the Timber program's costs and benefits constant, except for those directly associated with vegetation management. It also isolates those effects that are due only to vegetation management practices.

It shows for instance that the Present Value of the Benefits (PVB) is expected to increase in Alternative G by some $321 million due to increases in the level of timber production under that alternative. This is because under the theme of that alternative, some Forests expected that they could increase their level of timber production.

Costs associated with that increase in ASQ are estimated at $92 million. The overall ASQ effect is therefore clearly beneficial for Alternative G with over a 3:1 incremental Benefit/Cost Ratio. Costs tied directly to vegetation management decrease in their aggregate by $178 million in response to the use of lower cost methods of treatment.

The table shows rather clearly that the costs and benefits associated with changes in the ASQ dominate the economic analysis.

Table B-7

Economic Criteria Response to Changes in Allowable Sale Quantity (ASQ)

(1987 Million Dollars)

Alternatives	A	B	C	D	E	F	G	H
Total Change in PVB								
from Alt B[1]	$ -707	$ -0-	$ -6,212	$ -397	$ -282	$ -692	$ +321	$ -152
Due to ASQ Effects	-707	-0-	-6,212	-397	-282	-692	+314	-152
Due to Veg Mgt Practices[2]	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
Total Change in PVC								
from Alt B[1]	$ -110	$ -0-	-$ -3,441	$ -540	$ -243	$ -244	$ + 92	$ -148
Due to ASQ Effects	-234	-0-	-1,959	-152	- 87	-289	+120	- 58
Due to Veg Mgt Practices[2]	+344	-0-	-1,482	-388	-156	+ 45	- 28	- 90
Total Change in PNV								
from Alt B[1]	$ -597	$ -0-	-$ -2,783	$ +141	$ - 39	$ -455	$ +222	$ - 4
Due to ASQ Effects	-473	-0-	-4,253	-246	-195	-404	+200	- 94
Due to Veg Mgt Practices[2]	-124	-0-	+1,470	+387	+156	+859	+ 22	+90

[1] Components may not sum to the Total due to exclusion of livestock category.

[2] Vegetation management is an activity in support of a benefit. Its benefits are recognizable in other outputs such as timber production. Accordingly no benefit figure is presented on this line.

Table B-8 shows what would happen if the ASQ effect were only 50 percent of that which we used in our analysis, i.e., 50 percent of that shown in Table B-7. The analysis answers the question, "What if we overestimated the effect on the ASQ by a factor of two?"

From an efficiency point of view, Alternative C simply sacrifices too much in terms of timber harvesting. It retains its same tail-end standing in terms of PNV with and without this sensitivity test. The reduction in net timber benefits overwhelms the reduction in costs due to curtailing vegetation management activites.

Alternatives A, F, and H likewise fail to move in terms of their overall PNV rankings. They still hold positions 7, 6, and 4 respectively. Alternatives B and E switch places, as do Alternatives D and G.

These shifts occurred for a number of reasons. The most obvious is that the alternatives' PNV's are closely ranked—with the exception of C. Therefore, some changes in the rankings are expected.

Alternative G as originally constructed is the only alternative that projects an increase in ASQ from that estimated for Alternative B. This increase in ASQ generated increases in those benefits associated with timber harvesting that enabled Alternative G to generate the highest level of PNV. Without the full extent of the ASQ increase, it is supplanted in its top position in PNV by Alternative B.

Alternative D anticipated a sharp net decline in the costs of vegetation management. If this reduction in vegetation management costs can come about without the predicted falldown in allowable sale quantity, Alternative D looks very attractive from an economic efficiency point of view.

Table B-8

Economic Criteria Response to a Sensitivity Test Halving the ASQ Effect

(1987 Million Dollars)

Alternatives	A	B	C	D	E	F	G	H
Total Change in PVB								
from Alt B[1]	$ -353	$ -0-	$ -3,118	$ -199	$ -141	$ -353	$+154	$ - 76
Due to ASQ Effects	-354	-0-	-3,106	-199	-141	-346	+160	- 76
Due to Veg Mgt Practices[2]	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
Total Change in PVC								
from Alt B[1]	$ + 7	$ -0-	-$ 2,461	$ -464	$ -199	$ - 99	$+ 92	$-119
Due to ASQ Effects	-117	-0-	- 980	- 76	- 44	-145	+ 60	- 29
Due to Veg Mgt Practices[2]	+124	-0-	-1481	-388	-155	+ 46	+ 32	- 90
Total Change in PNV								
from Alt B[1]	$ -124	$ -0-	$ +1,470	$ +387	$ +156	$ - 51	$ +222	$ + 90
Due to ASQ Effects	-237	-0-	-2,127	-123	-98	-202	+100	- 47
Due to Veg Mgt Practices[2]	+113	-0-	+3,597	+510	+254	+151	+122	137

[1] Components may not sum to the Total due to exclusion of livestock category.

[2] Vegetation management is an activity in support of a benefit. Its benefits are recognizable in other outputs such as timber production. Accordingly, no benefit figure is presented on this line.

Appendix C

Herbicide Use and Efficacy

C

Appendix C

Herbicide Use and Efficacy

Table of Contents

Issues and Programs

Issues

Issues raised during scoping pertain to the amount of use and relative value of herbicides in meeting management program objectives. These include concerns such as:

- the effectiveness of control of important target plants;
- the relative increase or decrease of compound use;
- the primary methods of application and formulationsavailable;
- the management programs with large historical herbicidepro-grams;
- procedures for incorporating new products which display potential effectiveness; and
- hazards to nontarget vegetation and label constraints whichlimit product value in the forest setting.

The Operational Program

The years 1982 and 1983 provide a baseline for an operational program, approximating what may occur under Alternative B. The 16 herbicides addressed in this document account for essentially all of the herbicide use during the 1982 to 1983 seasons.

Table C-1
Typical Annual Acres Treated by Management Program

Application Method	Silviculture	Noxious Weeds	Rights-of-Way	Facility Maint.	Range Mgmt.	Total
Aerial Treatments	16,500	100	300	0	1,750	18,650
Ground Treatments	14,500	1,400	4,200	125	1,750	21,975
Total	31,000	1,500	4,500	125	3,500	40,625

Herbicide Descriptions

Compounds are described in descending order of use in the 1982-1983 program.

Table C–2
Forest Service Herbicide Use Before 1982, Pacific Northwest

	Herbicide	Percent of Treated Acreage
Major use	2,4-D	Approx. 38%
	Glyphosate	Approx. 31%
	Picloram	Approx. 8%
	Triclopyr	Approx. 7%
Minor use:	Dalapon	Less than 5%
(In order of	Atrazine	Less than 5%
approximate usage)	2,4-DP	Less than 5%
	Hexazinone	Less than 5%
	Fosamine	Less than 5%
	Dicamba	Less than 5%
	Asulam	Less than 5%
	Tebuthiuron	Less than 5%
	Diuron	Less than 5%
	Simazine	Less than 5%
	Bromacil	Less than 5%
	Amitrole	Less than 5%

2,4-D

TRADE NAMES: Weedone, Esteron, DMA-4, Formula 40, Weedar-64, and numerous others.

CHEMICAL NAME: (2,4-diclorophenoxy) acetic acid.

USE PATTERN: 2,4-D has been heavily used in the silviculture program (Plantation site preparation and conifer release) and has also seen regular use in the right-of-way maintenance and noxious weed control efforts. 2,4-D is often used in combination with other compounds—such as atrazine, dalapon, 2,4-DP, or picloram—to afford a

greater span of control. 2,4-D has long been (since the mid-1940's) a favored compound in other agriculture and forestry. A principal advantage is its relative selective control of broad-leaved weeds and woody shrubs, but a nontoxicity to most grasses. It is also less costly than several other herbicides which can be used in a similar vegetative composition.

The use of 2,4-D is decreasing proportionately in recent years as newer materials showing a greater degree of effectivness in controlling, specific target pests have gained registration for forestry application. 2,4-D, however, continues to be a herbicide of choice in a large number of chemical-use projects.

APPLICATION METHODS AND MODE OF ACTION: 2,4-D is a translocated phenoxy herbicide used in post-emergence applications. Uptake into plants occurs through foliage, and through stems to a lesser degree. It is translocated within the plant to regions of active growth, where it interferes with normal processes of cell wall development.

It is most often applied in a low volatile ester formulation by aerial or ground-backpack methods. Stump or frill treatments of an amine-salt formulation can also be effective on larger brush or weed trees.

Typical rates of application have been 1.5-4 lbs. A.E. per acre.

TARGET VEGETATION: 2,4-D has been highly effective in the control of many broadleaved weeds and herbaceous plants. It has also shown consistently good results with red alder, thimbleberry, and serviceberry. With the proper combination of seasonal timing and plant phenology, successful but less consistent results can also be seen with deerbrush ceanothus, snowberry, manzanita, Pacific madrone, and hazelbrush.

Cut stump or frill injection of 2,4-D amine has resulted in the initial kill and inhibition of sprouting species, such as red alder, California blackoak, madrone, willow, and chinkapin.

POTENTIAL NONTARGET PLANT EFFECTS OR USE LIMITATION: Several conifer species, ponderosa pine in particular, can be sensitive to 2,4-D damage if active tree growth is occurring. In conifer release, the herbicide must be applied when seedlings are dormant and brush is still growing. This period of opportunity will occur only during late spring and early fall. Even with carefully controlled project administration, there may be incidental conifer damage because of different phenological development of individual seedlings in the general popu-

lation, or changes in aspect or microsite, for example.

Because the mode of entry is primarily through foliage, and then translocation within the plant, it is often advantageous to use mid-range application rates if sprouting inhibition is important. This can help avoid the occasional problem with a too-rapid foliage kill and drying which can limit translocation of the chemical.

Glyphosate

TRADE NAMES: Roundup, Rodeo

CHEMICAL NAME: N-(phosphonomethyl) glycine

USE PATTERN: Glyphosate has been regularly used in the silvicultural program, and has proven effective for right-of-way maintenance, noxious weed control, and facilities maintenance. It is considered a broad-spectrum, relatively nonselective herbicide. It is one of the newer chemicals, having been first registered for use in 1974. It is a compound heavily used in agricultural and industrial situations, as well as for forestry. Its ability to control herbaceous vegetation, as well as shrubs, is an advantage in some situations.

The use of glyphosate, relative to other compounds, has been increasing in recent years. It has shown a good record of consistency in meeting prescription objectives.

APPLICATION METHODS AND MODE OF ACTION: Glyphosate is absorbed primarily through plant foliage. The specific mode of action is not entirely clear, but it appears to inhibit plant elongation, inhibit synthesis of essential amino acids, and to disrupt the photosynthetic process.

In forest applications, glyphosate (as Roundup), is applied both aerially and from the ground. Typical rates during 1982-1983 were 3 lbs., A.I. per acre (4.5-2 lbs. A.I. for conifer release).

TARGET VEGETATION: Glyphosate effectively controls many sedges, annual and perennial grasses, and broadleaved weeds. It has shown good results with the following woody brush: deerbrush ceanothus, blackberry, salmonberry, vine maple, red alder, willow, elderberry, bracken fern, and swordfern. It appears to be a good inhibitor of vegetative sprouting. However, the evergreen shrubs and hardwoods are not affected.

POTENTIAL NONTARGET PLANT EFFECTS OR USE LIMITATION: In conifer release applications, timing is more critical for effective brush control with glyphosate in comparison with some other herbicides, such as 2,4-D.

Picloram

TRADE NAMES: Tordon, Amdon

CHEMICAL NAME: 4-amino-3,5,6-trichloropicolinic acid

USE PATTERN: Picloram has seen regular use in noxious weed control, rights-of-way and facilities maintenance, rangeland improvements, and plantation site preparation. Use in release applications is limited due to the sensitivity of many conifers. It is a broad-spectrum chemical used to control a variety of woody plants, and annual or perennial broadleaved weeds. It can be effective in the control of weeds in grassy areas.

The relative use of picloram, in comparison to other herbicides, remains more-or-less constant.

APPLICATION METHODS AND MODE OF ACTION: Picloram is absorbed both by plant roots and foliage and translocated in the plant. It accumulates at the site of new growth where it is known to function as a plant growth regulator.

It can be applied by ground or aerially in solutions of liquid formulations applied on foliage. A water soluble amine salt is injected into plants or applied to cut surfaces. In this form, it has been used for elimination of weed trees and in precommercial thinning. Picloram pellets or granules are applied at the base of individual target plants where the active ingredient is leached to the rooting zone. It is sometimes applied in combination with 2,4-D for the improved span of control.

Typical application rates during 1982-1983 were .5 to .75 lbs. A.E. per acre, with a high of 1.08 lbs. A.E.

TARGET VEGETATION: Picloram is highly effective in the control of many noxious weeds, such as Canada thistle, leafy spurge, and Russian knapweed. Shrubs which have shown sensitivity include Scotch broom, salmonberry, snowberry, blackberry, and gorse. Injections and cut surface treatments have proven effective in control of many of the common hardwood species. Picloram can also have value where con-

trol of conifers is desired, such as utilities or roadside rights-of-ways.

POTENTIAL NONTARGET PLANT EFFECT OR USE LIMITATION: Picloram is persistant in certain soils because of the slow microbial degradation, particularly in cold climates. Breakdown in sunlight, however, is rapid.

Triclopyr

TRADE NAME: Garlon

CHEMICAL NAME: [(3,5,6-trichloro-2-pyridinyl) oxy] acetic acid

USE PATTERN: Triclopyr has been primarily used in the silviculture program, with application also made for rights-of-way and facilities maintenance. Some potential is also seen for rangeland brush control. It is a selective herbicide used for control of a variety of woody plants and broadleaved weeds. Established grasses are not injured at rates needed for weed and brush control. Garlon is a relatively new product in the mix of forestry herbicides.

Relative to other herbicides, the use of triclopyr has been increasing. This is because of its particular effectiveness in the control of root-sprouting species, and the fact that it was a replacement for 2,4,5-T (no longer registered by EPA) in some situations.

APPLICATION METHOD AND MODE OF ACTION: Triclopyr is absorbed primarily through the foliage and translocates within the plant stem. It accumulates in meristems, where similar to picloram, it interferes with the normal plant growth responses.

Triclopyr is applied both aerially and ground as an ester formulation; and as a cut surface, injection or basal spray as the triethylamine salt formulation.

Average application rates during 1982-1983 were 4 lbs. A.E. per acre (1.5 lbs. A.E. in release applications), and a maximum of 8 lbs. A.E. per acre.

TARGET VEGETATION: Cut surface or basal spray treatments have been effective on tanoak, Pacific madrone, red alder, live oak, bigleaf maple, California black oak, chinkapin, black cottonwood, and willow. Most conifers are also susceptible to cut surface applications. Spray applications can also be effective in the control of brush species such as tanoak, vine maple, blackberry, serviceberry, deerbrush, and snowbrush ceanothus.

An important feature of triclopyr is the ability to control some of the aggressively sprouting hardwood species.

POTENTIAL NONTARGET PLANT EFFECTS OR USE LIMITATION: Treated areas should not be grazed for one year following application.

Atrazine

TRADE NAME: AAtrex

CHEMICAL NAME: 2-chloro-4-ethylamino-6-isopropylamino-s-triazine

USE PATTERN: Atrazine has seen consistent use in many management programs for the selective control of grasses and forbs. Atrazine has been one of the most widely used herbicides in the U.S. since it's introduction in 1958. It is largely ineffective on woody plants.

Atrazine use has been relatively stable in the relative mix of forestry herbicides. It is often combined with other compounds for a broadened span of control. It displays a synergistic effect in combination with dalapon.

APPLICATION METHODS AND MODE OF ACTION: Atrazine is primarily absorbed through plant roots and translocated throughout the plant. It acts primarily as a photosynthetic inhibitor. Atrazine is used as a pre-emergent and early postemergent herbicide, and depends on adequate moisture to move the active ingredient into the rooting zone.

Atrazine has been applied both aerially and by ground methods. Typical application rates during 1982-1983 were 2-3 lbs. AI per acre, with a high of 4 lbs. A.I. per acre. Certain right-of-way maintenance situations have seen applications of 12.5-25 lbs. A.I. per acre.

TARGET VEGETATION: Atrazine is highly effective in the control of annual grasses. Only moderate control levels have been shown with perennial grasses and herbaceous vegetation. Canada thistle, leafy spurge, and horsetail are among the weeds susceptible to atrazine.

POTENTIAL NONTARGET PLANT EFFECTS OR USE LIMITATION: The effectiveness of atrazine depends on leaching to the plant rooting zone. Lower rates are needed on coarse-textured soils, while higher rates must be applied on fine-textured soil or soils high in organic matter.

Dalapon

TRADE NAME: Dowpon M

CHEMICAL NAME: 2,2-dichloropropionic acid

USE PATTERN: Dalapon has been used regularly in several management programs for the control of grasses. It is primarily used as a selective, postemergence herbicide in forestry. It has wide use for grass control in agriculture and industry. In the Western states, it is commonly used to control established perennial grasses along ditchbanks and noncrop areas.

Use of dalapon is relatively constant in comparison to other herbicides. It is often used in combination with atrazine, or other compounds.

APPLICATION METHOD AND MODE OF ACTION: Dalapon is readily absorbed through both plant roots and foliage, and then translocated throughout the plant tissues. The mode of action is not well understood, but dalapon acts as an inhibitor of both shoot and root growth.

The water soluble powder formulation of dalapon is applied both aerially and with ground equipment. Typical application rates are 3 to 7 lbs. A.I. per acre in site preparation and conifer release. Somewhat higher rates of 10 to 15 lbs. A.I. per acre are used in the range management and rights-of-way maintenance programs. When used for conifer release it should be combined with atrazine to prevent injury to Douglas-fir.

TARGET VEGETATION: Dalapon can effectively control annual and perennial grasses and some sedges.

POTENTIAL NONTARGET PLANT EFFECT OR USE LIMITATION: Dalapon must be applied when the grass is growing and before the seed heads form. Results will be poor if the grass is not growing well when application is made.

Livestock cannot be grazed on treated areas during the application season.

2,4-DP

TRADE NAMES: Weedone 2,4-DP, Weedone 170, and others.

CHEMICAL NAME: 2-(2,4-dichlorophenoxy) propionic acid.

USE PATTERN: 2,4-DP has been used, generally in combination with 2,4-D, in the silvicultural and rights-of-way maintenance programs. It has also seen occasional use in the range management program. It is one of the systemic phenoxy herbicides, and shows many similarities to the compound 2,4-D. It is more selective than 2,4-D, however. 2,4-DP has been used effectively on many woody shrubs and broadleaved weeds. As with 2,4-D, it is nontoxic to most grasses.

Use pattern with 2,4-DP is also similar to that of 2,4-D, in that it is declining. This is due to the fact that newer, broader-spectrum products are becoming available, and because it is almost always used in a mixture with 2,4-D. 2,4-DP is less harmful to ponderosa pine than is 2,4-D.

APPLICATION METHODS AND MODE OF ACTION: 2,4-DP is a translocated phenoxy herbicide with uptake primarily through the foliage, although basal stem treatments are sometimes used. After translocation, it interferes with the normal plant growth processes.

In forest applications, 2,4-DP is most often applied as a foliar spray in a low-volatile ester formulation. Typical application rates during 1982-1983 were 2-3 lbs. A.E. per acre, with maximums of 5 lbs. A.E. per acre.

TARGET VEGETATION: 2,4-DP can effectively control many broadleaved weeds and herbaceous plants. It has proven highly effective, in combination with 2,4-D, in the control of Pacific madrone.

Significant injury can also result in application to chinkapin greenleaf manzanita, and oceanspray. Basal treatments have shown good control of chinkapin and to a somewhat lesser degree, of bigleaf maple and cherry.

POTENTIAL NONTARGET PLANT EFFECTS OR USE LIMITATION: As with 2,4-D, most conifers can be sensitive to 2,4-DP damage if active tree growth is occurring.

Hexazinone

TRADE NAME: Velpar

CHEMICAL NAME: 3-cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4 (1H,3H)-dione.

USE PATTERN: Hexazinone has been used primarily in the site preparation and conifer release programs, and to a more limited extent in rights-of-way maintenance and noxious weed programs. It is a selective pre-emergent and postemergent herbicide in the triazine family. Unlike other triazines, hexazinone controls some shrubs, as well as grasses and forbs. It is one of the newest compounds to be extensively used in forestry applications.

Hexazinone use, in relation to other herbicides, has been increasing. An advantage in some situations is the good residual activity, with nearly complete control of a site possible for several years.

APPLICATION METHODS AND MODE OF ACTION: Hexazinone is absorbed through both the foliage and roots, with translocation primarily upward in the plant. The precise mode of action is unclear, but hexazinone appears to act as a photosynthetic inhibitor. While rapid contact activity may sometimes occur, it often takes a relatively long time period for damage to appear in the target vegetation.

Applications are made both aerially and with ground equipment. Formulations are available as a water soluble powder or granule form. Typical application rates are 1 to 3 lbs. A.E. per acre, although 6 to 12 lbs. A.E. have been used. Application rates vary according to the soil texture and organic matter content as well as the size and density of brush.

TARGET VEGETATION: Hexazinone effectively controls most broadleaved weeds and grasses. Some specific noxious weeds controlled are Canada thistle and starthistle. It can also effectively control small or young woody shrubs, such as manzanita. Hexazinone is very rate-responsive, depending on the type of target vegetation and the duration of control desired. It has application in plantation release programs, but exposure of conifers should be avoided.

POTENTIAL NONTARGET PLANT EFFECT OR USE LIMITATIONS: Rainfall after treatment (1/4 to 1/2 inch) is necessary to activate hexazinone. Hexazinone should only be used in new plantations when the planting stock is a least 2 years old. Newly planted containerized seedlings should not be exposed to hexazinone, because the potting

medium will not adsorb the herbicide, leading to injurious levels of uptake by the seedling.

Fosamine

TRADE NAME: Krenite

CHEMICAL NAME: Ammonium ethyl carbamoglphosphonate

USE PATTERN: Fosamine has had periodic use in the silvicultural and rights-of-way maintenance programs, although it is not currently registered for forestry application. It is a carbamate compound used as a postemergence, growth regulator, contact herbicide.

Its use has tended to decline in relation to other herbicides as newer systemic compounds became available for forestry applications.

APPLICATION METHODS AND MODE OF ACTION: Fosamine is absorbed by buds, stems, and plant foliage. It acts by inhibiting or preventing bud development.

It has been applied in liquid formulation by helicopter, broadcast ground application, and foliar on individual plants. Typical right-of-way concentrations have been 6-10 lbs. A.I. per acre, while release projects have been 3 lbs. A.I. Maximum rate during 1982 to 1983 was 12 lbs. A.I.

TARGET VEGETATION: Fosamine has been effective in salmonberry control. It can also provide satisfactory results in red alder, blackberry, and vine maple.

POTENTIAL NONTARGET PLAN EFFECT OR USE LIMITATION: Plants treated in the summer or fall will not show symptoms until the following spring when they leaf out. Only the portion of plant sprayed will show affects.

Dicamba

TRADE NAMES: Banvel, Banex

CHEMICAL NAME: 3,6-dichloro-0-anistic acid (or 2-methyl-3, 6-dichloro-benzoic acid)

USE PATTERN: Dicamba is a relatively nonselective herbicide used against a variety of broadleaved weeds and brush species. It has been

used in noxious weed control, rights-of-way maintenance, range rehabilitation, and plantation site preparation. It is phytotoxic to conifers, and can have particular value in some roadside maintenance situations.

Relative to other herbicides, its use has been fairly modest but stable. The dicamba compounds tend to be used when a variety of weeds and shrubs must be controlled on a site.

APPLICATION METHODS AND MODE OF ACTION: Dicamba has been applied aerially and by ground methods. It is often used as a cut surface injection or stump application. A granule formulation has particular application in noxious weed control situations where individual or scattered groups of plants will be treated. Dicamba is absorbed rapidly by foliage or roots, and is translocated within the plant. It acts as a plant growth regulator; altering shoot and root development. It also interferes with normal flowering and results in destruction of plant cells.

Rates of application during 1982 to 1983 were normally in the range of .5 to 1.5 lbs. A.I. per acre. The maximium during this period was 8 lbs. A.I. per acre.

TARGET VEGETATION: Dicamba is used against a wide variety of broadleaf weed and brush species. It can be effective in noxious weed control for Canada thistle, Russian knapweed, diffuse knapweed, tansy ragwort, and yellow starthistle. Basal treatments have proven effective in the control of red alder and hazel. Vine maple and willow have been controlled, but at reduced injury levels. It is also used in a formulation with 2,4-D to provide a broad span of control for broadleaved annuals and perennials, as well as woody shrubs.

POTENTIAL NONTARGET PLANT EFFECTS OR USE LIMITATIONS: The lower application rates for dicamba are for selective killing of annual broad-leaved plants, and the higher rated for total weed control.

Tebuthiuron

TRADE NAMES: Graslan and Spike

CHEMICAL NAME: N-(5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl)-N,N- dimethylurea

USE PATTERN: Use of tebuthiuron in the Pacific Northwest Region has been primarily in range management for the control of woody

vegetation, while grasses are allowed to continue growth. It is normally used in the dry formulations, as granules or pellets. It acts slowly, with plant death often not occurring for 3 years.

Tebuthiuron use has been limited, but the trend is for an increase relative to other herbicides.

APPLICATION METHODS AND MODE OF ACTION: Tebuthiuron is absorbed through the roots. The mode of action in plants is to inhibit photosynthesis, resulting in repeated defoliation. This eventually depletes carbohydrate reserves and results in the death of susceptible plants.

Applications have been by ground methods, or (rarely) by air (pellets). Average application rates have been .7 to 1.6 lbs. A.I. per acre, with a maximum of 8 lbs. A.I. per acre.

TARGET VEGETATION: Many brush, trees, and perennial broadleaf plants are controlled by tebuthiuron. It can also be used for control of annual weeds, some perennial grasses and weeds. Some noxious weeds, such as puncturevine, morning glory, spurge, and Russian thistle are also controlled by tebuthiuron.

POTENTIAL NONTARGET PLANT EFFECTS OR USE LIMITATION: Tebuthuiron should not be used around desired plants, or where their roots may grow into contact with the chemical. Vertical leaching in the soil is slow and no lateral chemical movement has been observed.

Asulam

TRADE NAME: Asulox

CHEMICAL NAME: methyl sulfanilylcarbamate

USE PATTERN: Asulam is a carbamate compound used as a selective, postemergence, systemic herbicide. It has been used periodically in the silvicultural and rights-of-way maintenance programs for the control of bracken fern, broadleaved weeds, and perennial grasses. It has had occasional use for fencerow and administrative site maintenance.

Asulam has been a minor but relatively stable component of forestry herbicide use.

APPLICATION METHODS AND MODE OF ACTION: Asulam can be applied in a liquid concentrate formulation by either aerial or ground methods. Asulam is absorbed rapidly by plant foliage and

roots, and then translocated within the plant. Signs of herbicidal action are yellowing of leaves, stunting of the plant, and death of the actively growing plant points. The visual signs of herbicide activity may not appear for 2 or 3 weeks.

Application rates averaged 3.34 lbs. A.I. per acre, with a high of 7 lbs. A.I. per acre during 1982 to 1983.

TARGET VEGETATION: Asulam can be particularly effective on bracken fern.

Diuron

TRADE NAME: Diuron, DMU, Karmex, and Krovar

CHEMICAL NAME: 3-(3,4-dichlorophenyl)-1,1-dimethylurea

USE PATTERN: Diuron is a substituted urea compound used as a pre- and postemergence herbicide. It is used as a soil sterilant in non-crop areas. It has had periodic use in the rights-of-way maintenance program for total vegetation control. It has fairly widespread use in agriculture for weed control in fruit, nut, and grain crops.

Diuron has been a small but stable component of the rights-of-way maintenance herbicide use program.

APPLICATION METHODS AND MODE OF ACTION: Diuron is rapidly absorbed through the plant root system and translocated to the aerial plant parts. Toxicity is due to the inhibition of photosynthesis, with leaf chlorosis occurring within several days to several weeks, depending on the rate of application used.

Average application rates during 1982 to 1983 were 5 to 10 lbs. A.I. per acre. Label-approved rates of up to 20 to 60 lbs. A.I. per acre are almost never used in forestry situations.

TARGET VEGETATION: Diuron can provide effective control of grasses and broadleaved weeds. Some specific weeds are foxtail, ragweed, ryegrass, and Johnsongrass. It is also used occasionally for control of aquatic weeds in fish hatcheries.

POTENTIAL NONTARGET PLANT EFFECTS AND USE LIMITATION: Diuron is relatively persistent in soils, and under typical soil texture and moisture conditions will not leach more than 6 inches below the soil surface. Microbial decomposition is the main mechanism of decomposition. A susceptible plant species should not be planted or seeded for at least 12 months after diuron application.

Simazine

TRADE NAME: Princep, Aquazine

CHEMICAL NAME: 2-chloro-4,60 bis (ethylamino)-5-triazine

USE PATTERN: Simazine is a selective triazine compound used as a pre-emergent herbicide for the control of grasses (primarily annuals) and broadleaved weeds. It has had minor use in the rights-of-way maintenance and plantation maintenance programs. It has only rarely been used for control of algae and aquatic plants.

Simazine has been a minor component of the herbicide use program. Other grass-killers are normally favored because of the tendency for simazine to bond tightly in the top 2 inches of soil.

APPLICATION METHODS AND MODE OF ACTION: Simazine is absorbed through plant roots, and shows no contact activity. It is translocated in the plant xylem system, where it interferes with a number of plant biochemical processes.

It has been applied by ground spot or broadcast methods. Rates during 1982 to 1983 were at 4 to 4.6 lbs. A.I. per acre.

TARGET VEGETATION: Simazine is effective in the control of annual grasses, and to a lesser extent with perennial grasses and forbs. It is sometimes applied in a mixture with atrazine. It is available in wettable powder, granule, and liquid suspension formulations. Some specific weeds controlled are knapweed, leafy spurge, Canada thistle, and dandelion.

POTENTIAL NONTARGET PLANT EFFECTS OR USE LIMITATION: Adequate moisture is required to activate simazine. It is relatively persistent, particularly in cold, dry, or infertile soils. It does not prevent germination, but destroys the plant after rooting.

Amitrole

TRADE NAMES: Amitrol-T, Amizol, and Weedazol

CHEMICAL NAME: 3-Amino-1,2,4-triazole

USE PATTERN: Amitrole is a nonselective, post-emergence herbicide which has occasional use in the rights-of-way maintenance program. An advantage of amitrole over some other compounds which afford similar vegetation control lies in product cost. Amitrole was patented in 1954 as a herbicide and plant growth regulator.

Amitrole has been a relatively insignificant compound if the herbicide use program. It is also formulated with simazine for use as a soil sterilant around buildings, storage areas, and parking lots.

APPLICATION METHODS AND MODE OF ACTION: Amitrole is absorbed by leaves and roots, and then translocated by both xylem and phloem systems within the plant. It affects a number of biochemical processes and tends to accumulate at the site of new growth.

Amitrole is generally applied by ground methods, although aerial helicopter application may rarely be used. Rate of application during 1982 to 1983 averaged 2 to 4 lbs. A.I. per acre. The approved label maximum is 20 lbs. A.I. per acre.

TARGET VEGETATION: Amitrole is relatively nonselective. It is particularly effective on annual and perennial grasses, and herbaceous vegetation. Some specific target plants have been poison oak, blackberry, thistles, and leafy spurge. It is effective on many root-suckering species of brush.

POTENTIAL NONTARGET PLANT EFFECTS OR USE LIMITATION: Conifers will be damaged by amitrole. Directions are to keep livestock out of treated areas during the season of use.

Bromacil

TRADE NAME: Hyvar, Urox B

CHEMICAL NAME: 5-bromo-6-methyl-3-(1-methylprophy) uracil

USE PATTERN: Bromacil has had some limited use in the rights-of-way maintenance program. It is used as a selective herbicide at normal use rates for control of a broad spectrum of broadleaved weeds, grasses, and some woody shrubs.

Bromacil has been a relatively insignificant component of the herbicide use program.

APPLICATION METHODS AND MODE OF ACTION: Bromacil is absorbed by plant roots. Adequate moisture must be available to activate bromacil. Toxicity is apparently related to the inhibition of photosynthesis within chloroplasts.

Applications of the wettable powder formulation have been by ground methods. Right-of-way use has been at the rates of 2 to

8 lbs. A.I. per acre, although a maximum could be as high as 30 lbs. A.I. per acre.

TARGET VEGETATION: Many annual and perennial weeds, and brush species can be controlled with bromacil. Some specific plants include cheatgrass, bracken fern, and foxtail. Some woody shrubs, such as willow and maple, can be controlled by basal spot applications. While absorption is primarily through roots, there is a limited amount of contact activity. This can be greatly increased with the use of a surfactant. It is also available in a formulation with diuron.

POTENTIAL NONTARGET PLANT EFFECTS OR USE LIMITATION: A more prompt plant kill occurs if bromacil is applied during the early part of the growing season. Deep rooted perennials can be difficult to control with diuron. Diuron is relatively slow acting, but seasonal or longer control of undesirable vegetation can be expected.

New Products

Herbicides not included for analysis in this EIS will periodically become available for use in forestry. These may be newly developed products, or the labelling of existing compounds for expanded uses. In this case, the potential use of these tools will be subject to certain process and analysis requirements:

1. NEPA Documentation. An analysis of potential environmental effects, which will be documented in a supplement or addendum to this document.

2. Human Health Risk Assessment—Worst Case Analysis. This is in response to the 1984 U.S. Court for the District of Oregon decision.

3. Decision Notice Signed by the Responsible Official. A decision will be made as to the appropriateness of use, and direction regarding use restraints or mitigation measures to be utilized in project implementation.

There appears to be a general reluctance on the part of chemical manufacturers to develop and register new products for use in forestry. This is apparently due to the fact that forestry use is a small component of the total pesticide market; and because it is difficult to recover the large investment needed for product development testing, and registration through the Environmental Protection Agency.

Two examples of herbicides that could be considered for future use on National Forest lands are:

Metsulfuron Methyl (trade name, Escort). This compound has been labelled for use in Washington and Oregon. It is registered for roadside use only, although there is some potential that site preparation use will be approved.

Sulfometuron Methyl (trade name, Oust). This compound is labelled for use in roadside or utility rights-of-way, and other uses. The primary advantage of these two chemicals is the fact that extremely low doses of active ingredients are needed for vegetation control.

Appendix E

Silviculture Program Effects

E

Appendix E

Silviculture Program Effects

Table of Contents

Program Size By Alternative and Method.

Site Preparation Alternative

Method	1,000 Acres, (%) A	B	C	D	E	F	G	H
No Treatment	10 (18)	8 (14)	0	17 (31)	8 (15)	8 (15)	6 (10)	12 (22)
Manual	6 (11)	3 (5)	0	3 (5)	5 (9)	9 (16)	4 (6)	3 (5)
Chemical	0 (0)	8 (15)	0	8 (15)	5 (9)	10 (18)	12 (19)	8 (15)
Mechanical	20 (36)	8 (33)	0	10 (18)	22 (40)	26 (47)	18 (29)	14 (25)
Biological	2 (4)	1 (2)	0	2 (4)	1 (2)	2 (4)	1 (2)	2 (4)
Thermal	17 (31)	17 (31)	0	15 (27)	8 (15)	0 (0)	21 (34)	16 (29)
TOTAL	55	55	0	55	55	55	62	55

Conifer Release Alternative

Method	1,000 Acres, (%) A	B	C	D	E	F	G	H
No Treatment	6 (17)	3 (8)	0	9 (25)	4 (11)	3 (8)	5 (10)	6 (17)
Manual	22 (61)	8 (22)	0	15 (42)	10 (28)	8 (22)	9 (18)	12 (33)
Chemical	0 (0)	21 (58)	0	7 (19)	18 (50)	21 (58)	30 (60)	14 (38)
Mechanical	3 (8)	1 (3)	0	2 (5)	2 (5)	2 (6)	2 (4)	1 (3)
Biological	4 (11)	2 (6)	0	2 (6)	1 (3)	1 (3)	3 (6)	2 (6)
Thermal	11 (3)	1 (3)	0	1 (3)	1 (3)	1 (3)	1 (2)	1 (3)
Total	36	36	0	36	36	36	50	36

Program Effects

There are several program effects (consequences) that apply to all alternatives. These include:

A. method effectiveness;

B. the substitutability of methods; and

C. the efficacy of herbicides (for all alternatives except A).

Method Effectiveness

Site preparation or release objectives defined in a site-specific silvicultural prescription can be met effectively by any method when applied to a specific performance level in the proper set of circumstances. These site-specific factors may include limitations and opportunities within an operational environment, the defined management objectives and standards, vegetative composition and predicted response, economic constraints, and logistical considerations.

Logistical considerations may include things such as the availability of equipment or labor sources, size or scale of operation constraints, seasonal "windows" of opportunity (which can limit project size), the spatial distribution of treatment areas, or variables in the sequence of events needed to successfully reforest a site (such as seedling availability and quality, planting quality, etc.). Method selection—or, in many cases, a decision to defer action—can only be addressed in a site-specific diagnosis.

A moderate level of damage to crop trees during vegetation management is anticipated and considered acceptable on operational projects. This may include scattered foliar, bud or leader damage during herbicide application, seedling trampling or browsing by livestock, or the physical crushing and deformity caused by manually treated brush. More severe levels of damage, however, can become a significant site-specific factor.

Examples of unacceptable herbicide damage to nontarget vegetation is documented by both Newton (1978) and Gratkowski and Lauterbach (1974), while heavy damage during manual cutting is seen in work by Hobbs and Wearstler (1985) and Roberts (1980). In the majority of treatments, however, crop tree damage is either transient in nature or the tree mortality not severe enough to cause a falldown in merchantable yields. Many of the studies used in Appendix A (Timber Growth and Yield Analysis), in fact, record an inconsistent height growth response following treatment for conifer release. This is partly a reflection of damage to individual trees. On a programmatic basis, a practice that consistently results in high levels of damage or deformity will simply be discontinued or modified to correct the problem.

Examples of successful use (i.e., meeting prescription objectives for tree establishment and early growth) of methods within these operational and biological limitations follow.

Mechanical

Site preparation through machine piling, scarification, chopping, mowing, disking or ripping, crushing, scalping or terracing has been used in relatively gentle terrain (slopes of less than 25 to 35 percent). These opportunities occur on all Forests, although most often on East-side or Transition Forests. Mechanical treatments have had limited application in the conifer release program due to the potential for excessive damage to growing stock trees. However, mowing equipment such as the Track-Mac and Hydroaxe, have been used in some East-side or Transition forest settings.

Machine site preparation can be especially effective where competing plants are dense and continuous (for example, many well established grass-forb complexes), or when root crowns or burls of sprouting woody shrubs must be removed. For machine treatment of sprouting species, timing can be important in order to reduce the vigor of vegetative sprouting. Operator proficiency and project administration are keys for successful manual treatments.

Soil properties must be critically examined prior to use of crawler or rubber-tired mechanical equipment for site preparation. Considerations may include soil depth and amount of coarse materials, compactibility, erosion potential, nutrient distribution and mixing of soil strata, or physical obstructions. Mechanical treatments often expose mineral soils and may encourage the rapid establishment of light-seeded annual grasses and forbs, or species such as alder which are prolific seed producers.

Mechanical and thermal treatments are often used in combination during site preparation. Machine piling of logging residues and fuels is generally followed by the burning of concentrations. In other cases, machine crushing or chaining may be followed with broadcast burning.

An average cost for recent mechanical site preparation has been $135 per acre. This will vary greatly according to circumstances and types of equipment. Some representative costs have included:

Dozer with blade	—	$80-$100/acre
Ripping and piling	—	$75-$160/acre
Disking	—	$70-$80/acre
Track-Mac	—	$150-$250/acre

Manual

Hand cutting, falling, girdling, grubbing, pulling, scalping, and mulching have been used for both release and site preparation. Scalping or mulching to reduce moisture stress to seedlings from grasses and herbaceous vegetation in new plantations is a common treatment throughout the Region. Cutting of woody shrubs or weed trees for site preparation is employed in the Coastal and southern and central Cascades subregion, often in combination with a direct herbicide application for inhibition of vegetative sprouting. All manual methods have been used for conifer release. Hand cutting, falling, or girdling have been utilized most heavily in the Coastal, central and southern Cascades, and Transition subregions.

The most rapid increase in manual release has occurred on Forests within the southern Cascades and southern Coastal subregions, which have had the largest historic herbicide-use programs. The operational effectiveness of these hand treatments is improving as knowledge is gained to better define phenological characteristics, treatment "windows", growth potentials, and effects on conifer survival and growth of the principle competing shrub and tree species. The duration of effectiveness of hand cutting is a concern when dealing with sprouting vegetation. As a Region-wide average, it has taken 1.8 manual cuttings compared to 1.1 herbicide treatments to adequately meet prescription release objectives. The physical volume of vegetation to be cut, and its potential for injury to growing stock seedlings, can be a limitation in the use of hand cutting in dense, older, or well-established brush fields.

Pulling or grubbing of germinants or young shrub seedlings has been employed for plantation release in the Cascades, Coastal, and Transition subregions. As with hand cutting, the most rapid increase in use of this method has occurred on Forests which have sizeable historic herbicide programs. Careful consideration of soil texture, percent of coarse fragments, soil moisture, and plant rooting depth is necessary for an effective pulling project. As a general statement, all of the manual methods can be especially effective when small or isolated areas must be treated.

The average costs for manual treatments have been $206 per acre for site preparation and $166 per acre for conifer release. This, of course, varies greatly by specific technique. Program size and regularity from year-to-year are particularly important in the development of a Forest-level manual program, in order to create the economy-of-scale

needed for operational use. Some typical costs for the different techniques have been:

Manual cutting (alder)	—	$50-$90/acre
Manual cutting (tanoak)	—	$150-$500/acre
Mulching (paper)	—	$70-$235/acre
Grubbing	—	$110-$160/acre
Pulling	—	$40-$200/acre

Chemical

Herbicide application through aerial (by helicopter or to a lesser extent, fixed-wing aircraft), mechanical (truck-mounted or towed sprayer), pressurized backpack ground equipment, or hand methods (injection, daubing of cut surfaces, or use of granular formulations) have been effectively used for both site preparation and release. Although herbicides have been utilized on all 19 Forests, the use has been concentrated in the southern Coastal, central and southern Cascades subregions. Chemical use in the East-side subregion has been primarily for site preparation. A discussion of target vegetation and the effectiveness of individual compounds is presented in Appendix C (Herbicide Use and Efficacy).

The southern Cascades area is where herbicides can most effectively be used to deal with the complex of competing vegetation, seasonal drought and precipitation patterns, and limitations due to rugged terrain. These conditions often occur in combination. The use of systemic, translocated herbicides can inhibit resprouting of many hardwood and shrub species, thereby improving the duration of treatment effectiveness in comparison to manual cutting (see the discussion on manual methods above). The potential for excessive damage to nontarget trees must be recognized, particularly for helicopter application of herbicides for conifer release.

Timing is normally critical in that application is made after crop tree height growth has ceased and buds have hardened, but while competing vegetation is still growing. Tolerance to herbicide exposure in conifers varies by tree species, type of herbicide, microclimate or aspect change, and physiologic factors related to growth of individual trees in the general population. While significant tree mortality is uncommon, damage to foliage or buds and leader deformity is serious enough to affect height growth response in an estimated 10 to 15 percent of aerial-release applications. A minor program (500 to 1,000 acres per year) of herbicide use to dessicate or kill vegetation—followed two to six months later by broadcast burning—would occur in Alternatives B and G.

Average cost for herbicide use during 1983:
(taken from GAO, Dec., 1986)

Aerial	—	$56 /acre
Ground (backpack)	—	$132 /acre

Biological and Grazing

The prolonged or forced grazing of cattle and sheep has proven to be effective in the release program, and site preparation to a lesser extent, when used in the correct vegetation complex and age of plantation. As with several of the manual techniques, the use of livestock for plantation maintenance is increasing as knowledge is gained in the areas of project logistics and administrative controls. The most effective operational programs can be found in the southern East-side (use of cattle) and southern Coastal (use of sheep) subregions. Grazing for release differs from the normal grazing program in that vegetation control, rather than animal weight gain or forage utilization, is the primary objective. Livestock use can be effective when palatable or preferred species are a significant component of the vegetation mix, and an area large enough to support the herd or band is available. Sheep can greatly reduce the vigor of competing shrubs and herbaceous weeds. Cattle have been effective in grassy plantations when moisture is not a significant limitation.

A major potential advantage of the method is cost efficiency. Annual cost for a six-year-old sheep-grazing project on the Siuslaw National Forest has been $12 per acre. Project costs, however, can be extremely variable, ranging up to several hundred dollars per acre. Another potential advantage is that grazing is normally socially acceptable and can be coordinated with wildlife management objectives. On some nutrient-deficient sites, the animals can be beneficial in that they convert vegetation directly into an available source of nitrogen. Grazing can also be coordinated with existing range permits, although the long-term objective is the availability of vendors that deal primarily with release contracts. Grazing is a precise method from the standpoint of administration, timing, and scale of project.

A consistent problem in the evaluation of these projects has been the establishment of a correlation between vegetation removed and the release effect in conifers. In other words, the heavy grazing of aerial plant parts may not necessarily translate into a measurable growth response in crop trees. Most potential adverse effects are related to these logistical factors. Timing is critical—utilization of competing vegetation must be complete enough to trigger the conifer release effect, but not so complete that animals start damaging seedlings.

A competent herder or rider can minimize crop tree damage by controlling animal bedding and movement. Full-time herders, however, can be difficult to find. Pasture fencing and good road access are often required. Nearby water sources are important, particularly with sheep. In some vegetation mixtures, the unpalatable competing species may simply increase as livestock reduce or eliminate the preferred plants. Inability to browse tall brush can be a limiting factor. Successful use requires careful consideration of plant palatability, crop tree size, steepness of terrain, availability of animals and herders, and adequacy of road access.

Thermal

Controlled burning prior to reforestation is commonly done over much of the Region. Burning for site preparation often has the additional objective of reduction of potential wildfire fuels. When done under the proper prescription, broadcast burning will create a favorable seedbed for natural regeneration, create plantable spots, or reduce the physical obstructions to reforestation.

The need for site preparation through burning is often greatest on steep terrain, where mechanical methods are impossible. This can be particularly true on some highly productive sites where the volume of competing vegetation and logging residues is large. The method is used on all Forests. As with herbicides, the relative amount of site preparation burning has been decreasing as Forests look for opportunities to operate within increasingly restrictive smoke management and air quality guidelines. Forests are also beginning to manage organic material for maintenance of site nutrient capital and productivity.

The need for, and effectiveness of, fire is even more sensitive to site-specific considerations than other methods. Effectiveness is determined by the proper prescription—that is, control measures, fire intensity and duration, weather and fuel moisture, the desired residual large fuels and duff cover, etc.

Effectiveness is also defined by a narrow time "window" in the spring or fall, when acceptable burning conditions exist. This means burning after fuels are suitably dry, but before the risk of an escaped fire is too great. Burning requires a relatively intensive administrative effort. If improperly used, broadcast burning can adversely affect site productivity. This can be especially true on high elevation sites or soil derived from granitic parent material, where much of the nutrient capital is contained in organic material and surface soils. The need for coordination to mitigate soil and water effects are emphasized in

Chapter IV of the EIS. Cost of site preparation burns fluctuate greatly due to factors related to terrain, weather patterns, vegetation, and project logistics. The average cost has been $238 per acre. This has ranged from $45 to $600 per acre in recent years.

There is much uncertainty concerning the long term effectiveness of burning as a site preparation tool. Improved short-term seedling growth following burning has been demonstrated in studies such as those documented by Stein (1986) and Barrett (1982). There has also, however, been speculation on potential reduction in long-term site productivity due to organic matter loss, nutrient volatilization, soil erosion, reduced mycorrhizal formation or increased soil pathogens. (Wagner and Radosevich, 1987).

Substitutability of Methods

Substitutability of methods is another major consideration within all alternatives. This means availability of vendors or equipment, the relative effectiveness of alternative methods, project size, or other logistical constraints which can limit or define management options. In a programmatic assessment, substitutability can only be addressed in general terms. At the Forest or District level of implementation, however, these factors are often the major consideration in program design. This is also the principal advantage of the availability of several techniques within a silvicultural program.

Some important considerations in the operational availabilty of these tools follow.

Mechanical Method Considerations

Some of the mechanized equipment is highly specialized: for example, the Track-Mac, Hydroaxe, and other mowing or chopping tools. In general, however, this equipment is readily available or easily adapted from timber harvest or road construction operations.

Mechanical site preparation projects can be sensitive to project size because of move-in/move-out cost considerations. As with any technique, operator proficiency and frequent monitoring is needed. This is especially critical in mechanical treatments because of the potential for considerable site or nontarget vegetation damage occurring in a short period of time.

Worker safety is always an important consideration when dealing with power tools on steep terrain or in dense brushfields.

Chemical Method Considerations

Herbicide projects, particularly aerial applications, can be constrained by project size and spatial arrangement of treatment units.
In the case of release programs, timing is critical to take advantage of the differing growth patterns of target and nontarget species. This means that a great deal of activity can occur within a short time frame during spring or fall within a subregion.

Contractor availability and coordination among units is critical in order to keep programs within reasonable size limits. A large support organization and logistical planning is necessary for aerial and large ground herbicide use projects. This involves not only overhead, air operations, support, observers, and monitors, but also support activities such as resource monitoring, medical facilities, or law enforcement, when necessary.

Worker safety, pesticide handling, storage, and disposal must be accomplished within rigidly defined direction.

For these reasons, pesticide-use projects can require a large investment of time and energy for a short period of time, compared to manual or mechanical silvicultural treatments.

Manual Method Considerations

The availability of contractors or a willing labor supply must be carefully monitored by a Forest in designing manual site preparation and release programs. Over time, contractor availability and bid rates will improve as programs increase in size and become more consistent from year to year. In the near future, however, Forests must carefully coordinate on the magnitude of manual programs to avoid "saturation" of the available vendors and willing labor pool. This has been particularly true in the case of release through use of powersaw and brush cutters.

Limitations on method substitutability (the ability to replace one method with another) are major operational considerations, and an important component of the assessment of consequences in Chapter IV. Factors can include logistical considerations, administrative factors, and limitations on the substitution of techniques. Specific assumptions are defined in Appendix A (Timber Growth and Yield Analysis).

It must be noted that "substitutable" does not necessarily mean "interchangeable" in terms of the efficacy of treatments. Appendix A, for example, is an effort to identify the specific situations in which early tree survival and growth will vary by treatment method. In other

words, the assumption is made that in certain combinations of vegetation, precipitation patterns, and operational environments, there are some intrinsic differences among the tools used for vegetation management.

By nature, the work is normally physically demanding, tedious, and moderately hazardous. Southwestern Oregon and northwestern California Forests have experienced erratic contract bid patterns, and some defaulting by contractors. These conditions should improve in the future, but will be significant factors in manual program planning for several years.

Biological, Cultural, Grazing Method Considerations

As with manual release and site preparation, the availability of vendors and animals within a reasonable distance often limits program size. Similarly, the situation should improve in the future as grazing for silvicultural objectives becomes more commonly employed.

This technique is being examined in research and administrative studies throughout the Western United States. In the near future, however, the number of willing operators is a limitation. The use of grazing for release is a precise technique in both timing and identification of an appropriate complex of vegetation. The treatment area must be large enough to support the herd or band. Careful administration, and often a full-time herder or rider, must be found. Doescher (1987), for example, stresses that not all forested areas are suitable for use of livestock as a silvicultural tool. Cited are limitations such as steep terrain, lack of palatable forage species, and absence of water or salt, which can make a site unsuitable for controlled cattle use. However, Doescher also documents some impressive tree growth enhancement when grazing for conifer release is used in the right set of circumstances (See Appendix A).

Forage utilized in a release effort is generally transitory in nature. This means that coordination of a project with the normal range permits is necessary. Some negotiation on grazing period or animal numbers with permittees is generally required.

Thermal Method Considerations

Burning for site preparation is limited to a relatively short time period in the fall or spring when fuel moistures are proper for consumption of fuels, but the risk of unacceptable resource damage is low. This time period also coincides with the bulk of burning for fuels reduction. The

amount of controlled burning to be done must be carefully matched to this "window" of opportunity.

The use of fire for silvicultural purposes often requires some previous treatment of vegetation in order to achieve objectives. Because fire or heat results in particulate matter production, units must comply with state smoke management guidelines set by agreements with individual states. This establishes limits on program size or timing.

The administrative impact of a burning program can be comparable to a large herbicide project. Personnel needs include staffing and equipping fire lines and control points; fire-weather support road or traffic control; safety support; and mop-up or reconnaissance crews. Logistical factors such as these are major considerations in the development of an operational burning program at the Forest level.

Efficacy of Herbicides

For those alternatives in which herbicide use is part of the silvicultural vegetation management program (B, D, E, F, G, and H), the efficacy of individual compounds has a large influence on effects or consequences.

Appendix C contains an assessment of herbicide historical use and trends, rates of application, modes of action, specific plant species controlled, and potential negative effects on nontarget plants. It also discusses some important use limitations for 16 herbicides—2,4-D, glyphosate, picloram, triclopyr, atrazine, dalapon, 2,4-DP, hexazinone, fosamine, dicamba, tebuthiuron, asulam, diuron, simazine, amitrole, and bromacil.

The analysis requirements and decision process to be followed for the potential use of any new products or expanded Environmental Protection Agency label uses are also addressed in Appendix C.

Consequences of the Silvicultural Program Specific to One Alternative

Timber Growth and Yields in the Absence of Vegetation Management

(Alternative C) Appendix A contains the analysis of yield effects in the absence of vegetation management for stand establishment and early maintenance to control site competition for moisture, light, or nutrients. The reduction in volume yields over time is related to a number of factors, which follow.

-A delay in early stand development due to vegetative competition that results in extended rotation length. This may result in either a prolonged culmination of growth or a delay in reaching a desired product size.

-An increase in tree mortality, vigor, or form defects, and suppression of growth that results in dead or submerchantable trees within a managed stand. This effect will translate into reduced commercial thinning opportunities and understocked areas within the stand.

-Restrictions on vegetation management options which lead to changes in the timberland suitability classification being made in the Forest land management planning. Specifically, these are conditions where the nonavailability of vegetation management presents a high risk of regeneration failure.

-A shift in species composition in response to early vegetative competition in mixed species stands. This effect can make factors such as growth patterns, susceptibility to physical damage or pathogens, or reduced product values a concern.

Yield effects are assessed for six vegetative complexes to present a cross-section of conditions in the Region, and to take advantage of the most pertinent available literature and information. Yield reductions are then estimated, based on a comparison to typical rotation length, site quality, and management strategy being used on intensively managed sites. These are the acres being managed for full or nearly full yields as projected in Forest Plan managed yield tables.

Vegetation Complex	Yield Reduction in the Absence of Vegetation Management (Percent)
Douglas-fir/alder	25%
Douglas-fir-hemlock/salmonberry/herbaceous	21%
Ponderosa pine/grasses-herbaceous	52%
Douglas-fir-ponderosa pine/Ceanothus spp./herbaceous	39%
Douglas-fir/tanoak-madrone	65%
True fir-hemlock/shrub/herbaceous	56%

Timber Growth and Yields in the Absence of Herbicide Use (Alternative A)

Appendix A contains a related analysis of the yield effects in the absence of herbicide use site preparation and release. The analysis considers biological effects, operational constraints, and physical limitations that may result in reduced treatment effectiveness in the absence of herbicide use.

Cost-of-doing-business and economic efficiency are not constrained in Appendix A. The budget levels and economic thresholds for alternatives are addressed in Chapter IV (Environmental Consequences).

Potential yield reductions are estimated for the loss of herbicide use in six vegetative conditions (vegetation complexes).

Vegetation	Complex Yield Reduction in the Absence of Herbicide Use (Percent)
Douglas-fir/alder	None
Douglas-fir-hemlock/salmonberry/herbaceous	None
Ponderosa pine/grasses-herbaceous	4%
Douglas-fir-ponderosa pine/Ceanothus spp./herbaceous	5%
Douglas-fir/tanoak-madrone	19%
True fir-hemlock/shrub/herbaceous	7%

Reforestation in the Absence of Prescribed Fire for Site Preparation

The use of fire as a site preparation tool would not be available under Alternative F. The magnitude of the burning program in general has been reduced in recent years as efforts are made to meet smoke management guidelines and reduce particulate emissions. This is particularly true of Forests west of the Cascade Crest. Within a Forest vicinity or major airshed, this requires coordination with other agencies, private timber operations, and agricultural and industrial programs.

The effect of broadcast burning on site quality and stand productivity can be either positive or negative. Use of fire as a management

tool can involve the risk of affecting the inherent soil properties. However, measurable effects on soil properties do not necessarily translate into reduced tree growth. Additionally, corrective actions (such as fertilization) can be a management option. The jury is still out on the net effect on subsequent tree growth as a result of controlled fire, but the local conditions will obviously define silvicultural options. Generally speaking, greater attention is being given to potential effects on long-term site productivity when burning is considered in the silvicultural diagnosis.

When used in the proper setting, prescribed fire will reduce physical barriers to reforestation, create plantable spots or microsite conditions, or prepare a seedbed for natural regeneration.

In certain situations, suspension of burning will have a negative effect on reforestation success. Site preparation(using prescribed fire) is commonly employed on steep terrain (40-plus percent) and often on highly productive sites where the physical volumes of unwanted vegetation may be large. Opportunities for substitution of other methods in lieu of fire are discussed in the following section.

If fire is not available when needed for reforestation site preparation, there will be five negative effects. These follow.

1. A reduced suitable timberland base available for intensive management: in extreme cases, the competing vegetation will present an unacceptable risk of regeneration failure.

Minimum acceptable stocking standards for newly established stands (certified as successful) are developed for combinations of timber type and site productivity. A high probability of failure to meet minimum standards (due to lost opportunities for site preparation) would mean reclassification of these sites as nonregenerable. This would mean removal of the site from the "suitable" land base in the Forest planning process.

2. An increase in nonstockable inclusions in managed timber stands: the effect is similar to the previous suitable land adjustment, but it occurs in areas too small to be identified in normal land allocation mapping and monitoring.

A typical effect is the creation of physical barriers and obstructions to planting, due to concentrations of undesirable vegetation or logging residues. Timber yields available from a stand must therefore be adjusted downward to accommodate the nonstocked or poorly stocked holes.

Based on Forest estimates, the combined effect (suitable land adjustment, plus inclusions) due to the lack of burning for site preparation is estimated to be 2-1/2 to 3 percent of the acres programmed for full or nearly full timber yields. The major impact would occur on Forests within the northern Coastal and southern Cascades subregions. Moderate adjustments would also occur on certain Forests in the East-side and Transition subregions.

3. A reduced tree growth and vigor in newly established stand: in some vegetative conditions, there will be an increased time lag in successful reforestation, or a reduction in early tree growth and vigor due to vegetative competition.

These effects will be highly dependent on site-specific conditions such as vegetation competition and stage of development, and limitations presented by the operating environment. Negative effects will be significant on sites with dense or older pre-existing vegetation, and those where timely reforestation efforts have not occurred.

The growth and yield effect in these situations would be comparable to the "no vegetation" management effects presented in Appendix A (Analysis of Timber Growth and Yield Effects).

The use of fire as a site preparation tool for reduction of interspecies competition must be carefully diagnosed as fit for the appropriate site conditions. If ground fire intensity and duration is not controlled, there may be adverse impacts related to site productivity and nutrient levels, as well as other soil and water considerations. Negative effects can also be related to the type, vigor, and amounts of competing vegetation if fire is used in the wrong situations. The end result will be a more difficult reforestation situation and a need for followup corrective action.

Examples of these more difficult reforestation situations include aggressive sprouting of woody shrubs or tree species. Fire may also trigger germination of seeds stored in ground litter and surface soils. Many of the widespread species of competing vegetation maintain long-term seed viability. The use of controlled fire often involves balancing fire fuels reduction goals with silvicultural and reforestation needs.

4. An increased loss of standing timber inventory due to wildfire: this means that timber growing stock and merchantable volume will be destroyed.

There will be an estimated 22,000 acres per year burned under

Alternative F due to increased occurrence of wildfire. Many of the fires are likely to start in stands where the treatment of logging residues and activity fuels has not occurred. This probably means that a relatively high proportion of young stands would be involved in the total burned-over area.

5. A reduced effectiveness may be seen in the establishment of natural regeneration.

Natural regeneration, either as the primary means of stand reestablishment or as supplemental stocking in planted units, is becoming increasingly important. Prescribed burning to prepare seedbeds and obtain natural regeneration is an important step following harvest cutting. Underburning of shelterwood and partial-cut units is also used to reduce slash volumes, prepare seedbeds, and retard the development of competing vegetation. Use of fire as a means to generate natural regeneration is most commonly employed in forest types of the Eastside and Transition subregions of Washington and Oregon.

In the long term, the use of broadcast burning will probably decline as a gradual shift is made from existing wild timber stands to second growth forests, with less unmerchantable material on site. However, burning will continue to be an important site preparation tool in a number of specific situations.

While difficult to quantify, the effect on the silvicultural program would probably be insignificant when viewed from a Region-wide perspective. On the Ranger District or project planning level, however, this can be a significant effect on both the reforestation and timber harvest planning programs. Both activities involve a systematic sequence of events over a several-year period. Disruptions caused by events such as large fires can adversely affect both amount and quality of program accomplishment at the District level.

The consequences of a suspension of burning for site preparation will be extremely variable on individual National Forests. A quantitative assessment of a reduced success in reforestation efforts can only be made within the context of site-specific considerations and limitations.

Silvicultural Program Effects by Alternative

Mechanical Methods

Mechanical site preparation is accomplished at high levels in Alternatives A, B, F and G. Moderate levels are used in Alternatives D, E and H, and none in Alternative C.

The effect of high level programs will be an improved record of early stand establishment. Most of the program increase over Alternative B levels would occur on East-side and Transition subregion Forests where terrain is more suitable for mechanized equipment. There is little difference in mechanical site preparation between Alternatives A, B, and F.

This indicates that opportunities for substitution of methods, such as thermal or chemical, for mechanical are relatively limited. The mechanical site preparation program remains relatively large in Alternative D. This reflects the fact that site preparation, by any method, is preventive in nature and will reduce the need for subsequent corrective actions in young stands.

Mechanical release through the use of mowing and chopping equipment is limited in all alternatives. Effects such as the potential excess damage to crop trees and marginal treatment effectiveness make the technique of relatively limited value in many situations.

Chemical Methods

Site preparation with herbicides is accomplished at a very high level in Alternative G, and large programs are maintained in Alternatives F and B.

The reduced use of chemicals in Alternative E is related to specific concerns for worker or public exposure to certain herbicide compounds. Herbicide use in Alternative D is greatly reduced, and is moderately reduced under H. There is no use of chemicals under Alternatives A and C.

As with all methods, increased use of herbicides in the appropriate site conditions and time will improve tree numbers and vigor in newly established stands. The increased use of herbicide site preparation under Alternative G will tend to be concentrated in East-side and Transition subregion Forests.

Herbicide release follows the same pattern as site preparation under various alternatives.

There is a large reduction of release with herbicides under Alternative D, which is proportionately greater than the change in herbicide site preparation. This reinforces the opinion that aggressive site preparation is normally preventive in nature. Alternatives with large herbicide release programs will result in improved growth and vigor of many managed stands (See Appendix A).

Manual Methods

Site preparation through scalping, grubbing, and mulching is done at high levels under all alternatives except C. This reflects the importance of early control of grasses and herbaceous vegetation in plantations. The proportionate increase is largest under Alternatives A, F, and D. This reflects a relative shift away from chemical or thermal use in these alternatives. The greatest relative increases in manual site preparation would occur on Forests within the East-side, Transition, and southern Cascades subregions. A general effect of large site preparation programs is increased success in planted seedling survival.

Large manual release programs will occur under Alternatives A, D, F, and H. More moderate sized programs would be seen under Alternatives G, B, and E. The large programs reflect additional restraints on herbicide use under Alternatives A and D. Increased manual release in Alternative F is related to the need for subsequent corrective action in the absence of thermal site preparation in some circumstances.

The greatest relative increase in manual release will occur in the central and southern Cascades, and southern Coastal subregions. Large programs of manual release will have the effect of improved growth and vigor in young managed stands. The duration of effectiveness is somewhat shorter than chemical release. Region-wide it has taken 1.8 manual treatments (compared to 1.1 herbicide applications) to achieve prescription release objectives. The need for more than a single manual release will be most common in the southern Coastal and southern Cascades subregions.

Biological, Cultural, and Grazing Methods

Opportunities for increased use of biological techniques are greater in the release program than in site preparation. There will be a slight increase in the use of forced grazing for site preparation under Alternatives A, D, F, and H.

Genetic adaptation through the Regional Tree Improvement Program also has favorable effects on seedling survival and vigor. Trees have evolved inheritable properties to deal with competing vegetation and site limitations. Seed and seedlings produced under a genetics improvement program may increase the effectiveness of site preparation. Several biological techniques have potential value in the silvicultural vegetation management program, but are not yet operationally effective (see Chapter II, Program Areas).

There will be an increased use of livestock grazing for plantation

release under Alternatives A, D, E, and F. Alternative B would see a more modest increase in the use of grazing. In the right mix of vegetation and under strict administrative control, the use of sheep or cattle can effectively produce a conifer release effect. Increased use of cattle will occur in the East-side and Transition subregions. Release through sheep grazing will become more common in the southern Cascade and Coastal subregion. Cattle use will occur primarily in grassy plantations. Sheep grazing can effectively reduce amount and vigor of herbaceous weeds and woody shrubs, in addition to grasses.

Thermal Methods

The use of fire as a site preparation tool is greatest under Alternatives G and A. Large programs will also be seen under Alternatives B, D, and H. The reduced use of site preparation through burning in Alternative E will slightly reduce the potential for adverse health effects due to air toxics or particulate matter. No thermal site preparation occurs under Alternatives F and C.

In many natural regeneration efforts, the use of fire is an important step in seedbed preparation. Loss of burning would reduce the effectiveness of regeneration efforts in these situations. Increases in the use of fire for site preparation would occur primarily in the Coastal and Cascades subregions, where steep terrain and high volumes of competing vegetation or logging residues make burning particularly effective. The use of fire to eliminate physical barriers and obstructions for planting is an important technique on Forests within the central and southern Cascades and the Coastal subregions.

Controlled burning has limited value in conifer release, other than in ponderosa pine stands of the East-side subregion.

Deferred or Nontreatment Methods

Deferral of treatment or "no-action" decisions are appropriate and common actions in silvicultural diagnosis and prescription under all alternatives. Increases in the number of no-action decisions are related to the damage thresholds and acceptable levels of uncertainty established in each alternative.

No-action decisions will be most common under Alternative D, in response to an emphasis on data collection and analysis, increased monitoring needs, and caution in creating situations which require followup corrective treatments. There will also be an increased willingness to delay action until research or administrative studies establish more conclusive evidence regarding species interactions, beneficial effects, and long-term site productivity implications of vegetation control.

A higher proportion of prescription decisions (approximately 20 percent) will result in no-action under Alternative H. No-action is also a common element in Alternatives A, B, E, and F. Alternative G will result in relatively aggressive management, an increased tolerance for uncertainty or missing research, and an increased willingness for corrective action in the site preparation and release programs.

A combination of budget restraints and the lack of herbicide use since 1983 has created a backlog of untreated release needs. These deferred treatment areas represent 30,000 to 40,000 acres, concentrated in the southern Cascades subregion. In certain combinations of competing vegetation, terrain, and precipitation patterns, there is an increased treatment effectiveness related to herbicide use (see Appendix A). This is primarily due to the inhibition of site reoccupancy by aggressively sprouting species. Alternatives which preclude the use of chemicals (A and C) would result in stocking or vigor loss within this backlog acreage.

Appendix F

Rangelands of the Pacific Northwest Region

F

Nearly pure stands of ponderosa pine occur throughout eastern Oregon and Washington. The structure of these stands varies, based on past management. Desirable understory grasses include Idaho fescue on central Oregon sites, pinegrass/elk sedge on northeastern Oregon and eastern Washington sites. White (grand) fir sites generally support, as desirable herbaceous understory, pinegrass or elk sedge. Major shrubs in central to southern Oregon include bitterbrush, mountain mahogany, snowbrush, manzanita, and big sagebrush. Northeastern Oregon and eastern Washington sites feature common snowberry, shiny leaf spirea, mountain snowberry, rose, and to a lesser amount, ninebark. Even in areas with a closed forest canopy, these shrubs and grasses still provide manageable and desirable forage.

Grasslands

The Cascade Range creates a prominent rain shadow which, in turn, greatly affects the vegetation of eastern Oregon and Washington. Vast areas of grassland and shrub/grasslands are found throughout most of eastern Oregon and central and southeastern Washington.

The most typical perennial bunchgrasses in this area include bluebunch wheatgrass, Idaho fescue, Sandberg's bluegrass, basin wildrye, and Thurber's needlegrass. The relative abundance of these five major grasses is variable.

The two most common plant communities are predominantly Idaho fescue with associated bluebunch wheatgrass. There are several recognized variations. The second major grouping is where bluebunch wheatgrass dominates over Sandberg's bluegrass. As was the case with Idaho fescue and bluebunch wheatgrass, even though these two bunchgrasses are the most abundant on a given site, there may be a variety of native herbaceous plants found in association with them. These sites exhibit different productivities and reaction to management. Pure stands of bunchgrass are very productive and are generally on more moist sites than areas supporting big sagebrush and bunchgrass.

Shrub/Bunchgrass

Sites supporting both shrubs and bunchgrasses are far more common throughout eastern Oregon and Washington than the previously described pure grasslands. Typical communities support major shrubs such as big sagebrush, antelope bitterbrush, rigid sagebrush, low sagebrush, snowberry, rose, mountain mahogany, and shadscale, in addition to the perennial bunchgrasses previously discussed (Table F-4). The most common shrubland association is represented by big sagebrush/bunchgrass, and is widespread throughout eastern Oregon and Washington.

In Oregon, shrub/bunchgrass sites are generally higher in elevation than are the Washington shrublands. Deep, loamy soils are not as common in eastern Oregon. Additionally, meadow grasslands supporting sod-forming grasses and herbs, characteristic of southeastern Washington, are nearly absent in eastern Oregon.

Juniper/Shrub/Bunchgrass

Western juniper is a fairly short (up to 40′ in height) conifer widespread throughout eastern Oregon, but mostly absent in eastern Washington. The combination of juniper/shrub/bunchgrass is very common in central Oregon, but only occurs as isolated stands on rocky sites or rims in most of eastern and southeastern Oregon. Most Washington sites support little or no juniper. The abundance of juniper shrublands today is attributed to lack of naturally occurring fire. Juniper has very thin bark, and is susceptible to fires. This probably explains its association with rocky sites, as in these areas there is little ground fuel to carry a fire to the tree.

The productive capability of juniper sites is similar to that of shrub/grasslands, but juniper may greatly modify the site. There is often need to control juniper growth or expansion since the tree is a strong competitor for moisture, nutrients, and as it grows, tends to block sunlight from ground vegetation.

Meadowlands

Meadowlands are very productive sites found over a wide variety of growing conditions. They typically support sod-forming grasses and sedges. Meadowlands in good condition also support a variety of herbs which are not, however, a dominant component of the vegetation.

There are three major subdivisions applied to meadowlands: 1) dry, 2) moist, and 3) wet. These sites are productive and often near a water source. These conditions attract livestock, and these sites rarely exhibit good native conditions.

The distinctions between dry and wet meadows may best be characterized in relation to water and vegetative composition. Most dry sites are mid-elevation and lower, and support primarily the introduced—but highly palatable—Kentucky bluegrass. These sites tend to occur on better-drained soils, and are generally the greatest distance from ground water.

Moist meadowlands are dominated by a combination of tufted hairgrass, a lesser amount of Kentucky bluegrass, and a number of sedges. Slightly closer to ground water than the dry meadowlands, these sites stay wetter for longer periods of time. More woody vegetation is also associated with the moist sites in the form of willow, alder, and aspen.

Table F–1

Summary of Forest and Rangeland Under Other Ownership (Thousand Acres)

	Forest land		Rangeland	
State	Other federal	Non-federal	Other federal	Non-federal
Oregon	4,938.0	11,112.1	11,312.7	9,186.9
Washington	1,050.3	24,818.8	1,019.7	6,227.4
Total	5,988.3	35,930.9	12,332.4	15,414.3

Table F–2

Percent of Land Grazed Under Each Ownership

State	Other federal	Non-federal
Oregon	79	70
Washington	38	58

Table F–3

Summary of Range Statistics for National Forests in the Pacific Northwest: Fiscal Year 1986

	Oregon	Washington
Number of grazing allotments	599	186
Number of active grazing permits	712	200
Number of cattle authorized to graze	122,100	22,400
Animal unit months (cattle)*	546,700	113,900
Number of sheep authorized to graze	44,900	10,000
Animal unit months (sheep)*	50,800	9,700
Number of horses authorized to graze	7,462	21,100
Animal unit months (horses)*	2,300	3,700
Number of wild horse territories	2	0

**One animal unit month (AUM) is the forage requirement for one month for a 1,000 pound mature animal (cow) or its equivalent (5 sheep).*

Table F–4

Summary of the Six Major Ecosystems Grazed in Eastern Oregon and Washington on National Forest Lands (1987)*

	Meadows	Grassland	Shrubland	Juniper	Timber Shrubland	Timber Transitory
Okanogan	12,000		62,000		414,000	228,900
Wenatchee	43,300	65,000	100,300		192,500	41,256
Colville	8,500				165,500	720,000
Umatilla	12,317	212,360	43,936	21,224	860,100	236,149
Wallowa-Whitman	7,958	501,624	22,621	4,724	807,677	809,560
Malheur		43,199	103,527	55,692	431,305	678,685
Ochoco	18,400		97,350	184,900	687,450	43,900
Deschutes	5,773		31,507	4,917	150,000	1,311,761
Fremont	37,283		138,731	171,000	238,000	111,000
Winema	12,294		10,643	13,507	325,090	294,762
Mt. Hood	2,652		159		6,636	265,769
Total	189,574	822,183	610,774	456,064	4,278,758	4,741,746

Source—Personal communication with listed forest.

**These acres represent only those acres that are considered suitable in terms of vegetation potential and steepness of slope.*

Almost imperceptibly lower in elevation, the wet meadowland type occurs either as a small narrow inclusion adjacent to intermittent or perennial streams or in large wet basins. The dominant vegetation is generally mostly short to tall coarse sedges to the almost total exclusion of grasses. Willow and alder are the major woody plants. These sites will commonly exhibit surface moisture into September.

Further upslope in the subalpine setting, a variety of other meadowland types are recognized. These sites may occur as pure meadows, shrub/meadows, or sub-alpine parklands. Dominant vegetation includes herb/sedge, heath-huckleberry/herb, or high elevation conifers extending into the aforementioned settings. On some of the drier sites, green fescue, a bunchgrass, is dominant with only limited potential for shrub growth.

Transitory Range

The total acres considered to be transitory range in forested settings is significant (Table F-4) and constitute a larger acreage than the yearly grazed forested/shrub/grass types. The transitory acres found in forestlands are generally very productive due to deep soils and increased precipitation. Although ponderosa pine may still be codominant in specific locations, there is a noticeable presence of grand fir, white fir, larch, and Douglas-fir. One or more of these species may grow in combination with ponderosa pine. Usually there is considerable diversity in shrubs after the site has been logged.

In addition to the major shrubs previously discussed, two evergreen shrubs are important. Following intensive logging activity, snowbrush, a moderately palatable low-statured shrub up to 2 meters in height, or manzanita, generally a non-palatable shrub of similar stature, will often form a continuous canopy across the treated area. While snowbrush offers some browse and manzanita little to none, both plants are aggressive seral species. When fully developed, they may essentially eliminate all herbaceous vegetation by shading and through competition for nutrients and moisture.

Transitory forested rangelands often occur at midslope and higher location on the landscape. Even though these sites are very diverse and productive the range opportunities are often limited, due to aggressive shrub development and total tree/shrub competition. This often leads to heavy shading and elimination of herbaceous vegetation. On the other hand, the high elevation stands may exhibit low plant diversity, but offer few range opportunities due to the often extreme environment.

Appendix G

Vegetation Management Activities

G

Appendix G

Vegetation Management Activities

Table of Contents

This appendix contains a discussion of Forest Service management that would be affected by selection of one of the vegetation management alternatives. These programs include plantation site preparation, conifer release, fire management activities, range improvements, noxious weed control, wildlife habitat improvement activities, maintenance of recreation facilities and administrative facilities, rights-of-way, tree genetics activities, and research.

Reforestation—Site Preparation and Release

Site preparation for establishment of artificial or natural regeneration in managed timber stands is often necessary for prompt reforestation success in the Pacific Northwest Region. It commonly involves control of competing vegetation in conifer plantations for management of several components of the seedlings' environment. These can include: soil water availability, light availability for shade-intolerant species and reduction of pathogens in surface litter. They also include limiting habitat (including food sources) for rodents and invertebrates that damage seedlings, physical injuries from litter fall, reduction of fire fuels that hamper future stand protection, and reduction of physical barriers to tree planting.

Release is the practice of controlling the density, composition, and vigor of competing vegetation during the period of seedling establishment. The objective is to maintain satisfactory survival and early development of the desirable vegetation. The environmental components being managed are similar to those in site preparation activities. Site preparation and release are utilized within the first five to ten years in the life of managed tree stands and may often be done as dual purpose projects. A common goal is to control the relative dominance of crop trees, excess hardwoods, and shrub or herbaceous vegetation while seedlings develop to a size and rooting depth which ensures their survival and future growth. A key factor in the success of release efforts in all provinces has been early treatment following site disturbance (logging or fire). Prompt treatment, when competing or invading vegetation size and density is relatively manageable, allows flexibility in method selection and a high probability of meeting prescription objectives.

Statutory Authority, National Program Goals, and Existing Policy

Basic authority for these silvicultural activities is contained in the following laws:

1. Organic Administration Act of 1897
2. Knutson-Vandenberg Act of 1930
3. Bankhead-Jones Farm Tenant Act of 1937
4. Granger-Thye Act of 1950
6. Supplemental National Forest Reforestation Act of 1972
7. Forest and Rangeland Renewable Resources Planning Act of 1974
8. National Forest Management Act of 1976
9. Reforestation Trust Fund, Title III, Reforestation, Recreation Boating Safety and Facilities Improvement Act of 1980

Policy Statements include six principle directives, which are further defined in Agency technical handbooks. These directives are:

1. Use only those practices best suited for the land management objectives of the area.
2. Prescribe treatments that are practical in terms of preparation and administration costs.
3. Monitor practices to determine that objectives are met.
4. Prior to scheduling stands for regeneration harvest, insure, based on literature, research, or local experience, that stands being managed for timber production can be adequately restocked within five years.
5. Inform minorities and women about opportunities in contracting for activities.
6. Perform all silvicultural activities in the most cost- efficient manner consistent with resource management objectives.

The young stand maintenance program in the Pacific Northwest Region is a significant portion of total Forest Service accomplishment in this area. In recent years, the site preparation program has averaged 45,000 to 75,000 acres annually, while plantation release has averaged 30,000 to 55,000 acres. Yearly fluctuations will occur on a Forest as a result of silvicultural systems or logging activity, budgets, seedling availability, weather or personnel limitations, priorities identified in the Forest Plan, or special programs.

Methods Considered For the Program

All methods have proven successful in meeting site preparation and release objectives under the appropriate biological and operational conditions.

Herbicides

While herbicides have been utilized in reforestation programs on all 19 National Forests, the technique has been concentrated on certain Forests. For example, in 1982, four Forests (Siskiyou, Siuslaw, Umpqua, and Willamette) accounted for 62 percent of the herbicide treatment acres. Herbicide need and effectiveness is greatest where a combination of the complex of competing vegetation, seasonal drought and precipitation patterns, and relatively rugged or remote terrain limitations exist in combination. These qualities exist within portions of the Siskiyou and Western Cascade Provinces.

Mechanical

The use of machine piling, mowing, disking, crushing, or terracing can be effective on relatively gentle terrain (slopes of less than 25 to 35 percent). This technique is principally used in the site preparation program. Mechanical treatment can be effective in removal of root crowns of sprouting shrubs where excessive soil movement or compaction can be avoided. The method is most often used where physiography is less limiting—such as the Upper Basin and Range, Harney Basin, and Blue Mountain Provinces.

Manual

Hand felling, girdling, grubbing, pulling, scalping, mulching, and shading have proven effective when applied in the appropriate circumstances. Manual release methods, in particular, have become increasingly important since the 1983 U.S. District Court injunction on herbicide use within the Pacific Northwest Region. Manual techniques have been most effectively used in moderately severe competing vegetation (for example, red alder or several of the ceanothus species) when costs, work force limitations, and period of treatment effectiveness can be managed to achieve prescription objectives. Manual methods are utilized Region-wide, but Forests with historically large plantation maintenance programs have been most aggressive in their utilization.

Biological

Domestic livestock (sheep and cattle) have been the most significant biological factor in the silvicultural program. Prolonged, or "forced" grazing and browsing can reduce grasses, herbaceous, and palatable shrub competition to the point that a release effect is seen in crop trees. The animals, especially sheep, must be carefully controlled and herded

to achieve the desired results. This has proven to be cost-effective when factors such as band or herd availability, and a relatively large administrative impact are not limitations. Sheep use has proven effective within the Coast Range Province. The potential for cattle use is greatest in the Harney Basin and Upper Basin and Range Provinces which are characterized by pine and grass-shrub plant communities.

Burning

Broadcast burning is a common treatment prior to reforestation. While the technique is primarily used for removal of logging residues and fuel accumulations, it can often have a site preparation objective. This may involve creation of a favorable seedbed for natural regeneration, creation of planting sites, or reduction of physical obstructions to reforestation. Broadcast burning is most commonly used in clearcuts on steep slopes where machines cannot be used.

Limitations on the technique involve smoke management and air quality standards, a relatively narrow prescription window (when fires and weather conditions allow effective burning at a low risk of escape), and potential adverse soil nutrient or vegetation response effects. In some situations, a ground fire of moderate intensity may trigger germination of brush or weed seed loads, or vegetative sprouting, which can aggravate site competition for moisture, nutrients, and light. Burning for silvicultural objectives has been effectively used over a large portion of the Region.

Combinations of Methods

Several combinations have been effectively used to meet silvicultural objectives:

- Machine piling of logging residues and fuels, followed by burning of concentrations.
- Machine crushing or chaining, followed by broadcast burning.
- Aerial herbicide use to desiccate or kill vegetation, followed in two to six months by broadcast burning.
- Hand felling of hardwoods or large woody shrubs, followed by burning.
- Hand felling and daubing of cut surfaces with systemic herbicides.
- Hand cutting of large stems and injection of a systemic herbicide for translocation to the root system and aerial plant parts.

Dimensions of Treatment Methods

Spatial limitations are often a factor in method preference. The number and distribution of treatment areas must be large enough to allow an administratively efficient project. Project size considerations are particularly important in grazing of livestock, burning, and aerial herbicide treatments in site preparation or release programs.

Management intensity is also an important dimension in determination of methods. Aggressive or prompt plantation establishment and release is normally limited to lands suitable for intensive management—for timber yields approaching the biological potential on a given site. Biological potentials are defined by stocking levels, growth rates, and timber yields in development of the Forest Land Management Plans. On lands where timber yield levels are reduced or secondary in importance to other resource values, the no-treatment or deferred treatment may sometimes be the preferred silvicultural option.

Several techniques have limited use in site preparation and conifer release projects, or are very site-specific in application. They include:

1) Biological herbicides: Naturally-occurring microbial and several agents have proven effective in insect suppression and agriculture. Use in Forest vegetation management is not yet operationally effective.

2) Fertilization: Fertilizers have been used to control vegetation in some roadside maintenance situations, but use in plantation maintenance has not been demonstrated.

3) Genetic adaptation: Trees have evolved heritable properties to deal with competing vegetation and site limitations. Seed and seedlings developed by the Region's Tree Improvement Program may eventually reduce the need for release in certain situations.

4) Firewood removal: Commercial or personal-use roundwood removal for fuelwood can reduce unwanted vegetation in some locations. This is highly dependent on local demand and ease of access.

5) Insect control: Release of introduced insects to weaken or kill specific target plants has proven effective in certain noxious weed situations. This is not applicable in plantation maintenance where precise timing and span of control—a variety of plants—is generally needed.

6) Pathogenic control and allelopathy: Use of introduced pathogens and chemicals produced by plants to repel or inhibit competitors is still experimental in forest management.

Fire Management Program

Background

The fire management program within the Pacific Northwest Region developed early in the 20th century in response to a series of devastating wildfires. Initially, the policy stated that all wildfires were to be controlled, regardless of cost, by 10 a.m. the day following discovery. The 10 a.m. policy remained in effect for 43 years. In 1978, the policy was rescinded as a result of increased awareness of fire economics and resource values. Today, the policy is to suppress all wildfires in a timely and safe manner. Suppression strategies are used which minimize both suppression cost and resource damage.

The fire program consists of activities undertaken for the protection of resources and other values from wildfire, and the use of prescribed fire to meet land and resource management goals and objectives. The Region spends approximately $26.4 million annually to protect 26.0 million acres.

Protection activities include fire prevention, detection, and suppression, and fuels management. The Region has an extensive suppression organization comprised of smokejumpers, hand crews, helitack crews, air tankers, engine crews, and fire overhead teams. Suppression forces can be mobilized and transported to remote locations throughout the Region quite rapidly.

Detection of wildfires is accomplished by a variety of methods. Fire lookout towers are still used on many Forests, but some are used only during periods of high fire danger. Ground patrols often are used during periods of high fire danger and aerial patrols are quite effective in inaccessible terrain. Recent detection advances include the addition of electronic lightning detectors. The electronic lightning detector, in conjunction with a computer, charts the location of known lightning strikes.

The purpose of wildfire prevention is saving lives and avoiding unacceptable losses to resources, property, and improvements. The Region coordinates with local, state, and other federal agencies to ensure that prevention efforts are successful. The prevention program is targeted for all Forest users, both recreational and industrial.

Fuels management consists of planning and executing the treatment or control of living or dead vegetative material. Fuels are treated to provide cost-efficient resource protection and to meet land

management objectives. Currently, about 200,000 acres are burned annually to manage fuels. Logging slash accounts for about 160,000 acres of the total acres burned.

The use of prescribed fire for the protection, maintenance, and enhancement of resource productivity is also a part of the fire management program. Fire can be cost-effective and used whenever practical when carefully planned and administered.

Authority and Legal Requirements

The following Acts contain legal requirements and authorities to plan and carry out activities to protect National Forest System lands and resources from fire:

1. Act of June 4, 1897 (16 U.S.C.551)
2. Bankhead Jones Farm Tenant Act, July 22, 1937
3. National Forest Management Act of 1976
4. Wilderness Act of Sept. 3, 1965
5. Endangered American Wilderness Act of 1978
6. The Clean Air Act Amendments of 1977
7. Clarke-McNary Act of 1924

Implementation

The National Fire Management Analysis System (NFMAS) is used to determine fire suppression resource and program needs at the Regional and Forest level. The system provides a consistent budget analysis process for evaluating the efficiency and effectiveness of fire management programs. Direction for forest fire protection and use programs, appropriate to meet resource targets, is developed from resource management objectives and prescriptions through the Forest planning process.

Site-specific fuels treatment alternatives are developed through the interdisciplinary process. A team of resource specialists evaluates a proposed activity and recommends needed fuels treatment. Treatment for protection purposes is based upon historical fire occurrence, expected fuel loading, expected fire risk, and expected fire hazard. Treatment methods are selected after careful evaluation of the site. Factors such as slope, stability, vegetation type, soil compactibility, erosion potential, and smoke management restrictions are considered prior to selecting a treatment method.

Methods

All methods of managing unwanted vegetation are appropriate for fire management activities. The Region's preferred method of managing unwanted residue is utilization. Opportunities to use residue are actively pursued before other methods are considered.

Other treatment methods are used if residue utilization fails to meet fire management objectives. Prescribed fire (the controlled use of fire under predetermined conditions) frequently is used to accomplish fire management objectives. Fire is used alone and in conjunction with other vegetation management methods such as yarding of unmerchantable material (YUM), machine and hand piling of slash, and machine crushing of slash. Use of fire requires close coordination between federal, state, and local agencies to ensure that impacts of smoke on air quality are minimized.

Chemicals used in fire management activities generally are limited to fire retardants and alumagel. Retardants are sometimes used for fireline on prescribed fires. Alumagel, a gasoline thickening agent, is used as helitorch fuel to ignite prescribed fires. Alumagel is also used to ignite large slash piles for disposal during wet weather conditions. Chemicals are seldom used to desiccate vegetation prior to burning.

Range Improvement

The rehabilitation of deteriorated rangeland, protection of rangeland from degradation, or improvement of forage quality or quantity often requires manipulation of vegetation. Rangelands that become less productive due to overgrazing or through natural changes in vegetation (succession) must be managed to meet the objectives established for them (i.e., increased range vegetation diversity, improved wildlife habitat, or watershed). These changes occur more rapidly in the absence of fire, and tend to lead to a dominance of shrubs over herbaceous plants and an overall reduction in plant species diversity.

Range improvement activities are carried out primarily under provisions of the Federal Land Policy and Management Act of 1976 and the Public Rangelands Improvement Act of 1978. In recent years, vegetation management has taken place on approximately 2,000 to 4,000 acres of rangeland annually.

On National Forest System lands in the Pacific Northwest, grazing of domestic livestock takes place on approximately 6.7 million acres in 807 grazing allotments. Management of each grazing allotment is

governed by an Allotment Management Plan which identifies site-specific capabilities, grazing systems, and intensities. It also includes structural and nonstructural range improvement projects necessary to implement the selected grazing system. Planning for individual vegetation management projects (a form of nonstructural range improvement) involves environmental and economic considerations, and is documented in an Environmental Assessment or Categorical Exclusion.

The most common targets of vegetation management activities are sagebrush, rabbitbrush, and western juniper. These woody species may increase on rangelands where fire has been excluded or overgrazing has occurred. Growth of these species occurs at the expense of more palatable grasses and forbs. Control reduces the density of shrubs and trees, allowing increased production of more desirable herbaceous understory vegetation. Treatment may also be necessary to restore the productivity of disturbed meadows in forest zones, or abandoned fields on the Crooked River National Grassland.

Methods

Herbicides

Herbicides have been applied either from the air or ground to eliminate or control unwanted plant species such as sagebrush and rabbitbrush.

Mechanical

Various mechanical techniques are used to manipulate vegetation for rangeland improvement, including chaining, cabling, crushing, and scalping. These techniques are most commonly used on brush to induce resprouting for improved browse and to reduce competition to favor herbaceous forage. Plowing is used on productive sites to control small, shallow-rooted plants and prepare a seedbed. Chaining breaks plants off or pulls them over, and is accomplished by dragging a heavy anchor chain in a U-shape behind two crawler tractors. Crawler tractors with brush or dozer blades are used to push over and pile unwanted woody or brushy species.

Manual

Manual techniques (such as cutting shrubs or trees encroaching on meadows) are used on a limited basis to control brush or other vegetation. Cutting is also prescribed to regenerate aspen stands. While this is usually done to improve wildlife habitat, early successional plant stages can also provide forage for livestock.

Biological, Cultural, and Grazing

Noxious weed control is an important activity conducted in conjunction with rangeland improvement projects. It is discussed in detail in the following section. Biological control efforts have involved the utilization of predators, pathogens, and parasites as natural enemies for the control of certain noxious weeds.

The majority of cultural control methods used are seeding with grass/legume, forbs, and shrub species to provide improved forage conditions for livestock while protecting wildlife habitat, preventing degradation of rangelands, and providing competition to noxious weeds. This method is used to prevent noxious weeds from becoming established on disturbed sites during improvement projects. Planting of desirable shrub species can be done in combination with mechanical and manual techniques.

Grazing and browsing by domestic livestock has controlled shrubs and reduced unpalatable portions of herbaceous forage in some rangeland areas. An indirect benefit of this activity has been that new plant growth is made available to wildlife.

Grazing activities that are properly timed and controlled have potential noxious weed control benefits. Grazing of livestock that are tolerant of the toxins produced by noxious weeds is used to control the composition or amount of the infestation. This technique has been used in some cases to control weeds on a limited basis (for example, the use of sheep to consume tansy ragwort).

Control of some species can be accomplished through the use of grazing animals such as goats.

Prescribed fire

Prescribed fire is the most commonly used form of vegetation management.

Noxious Weed Control Activities

Noxious weeds are defined by both federal and state laws. They are species of plants that cause disease or are injurious to crops, livestock, or land, and thus are detrimental to agriculture, commerce, or public health (PL 93-629, ORS 570.505, RCW 17.10). Many species are harmful to agricultural crop production, or are toxic to livestock that ingest

them. Designation of species as noxious weeds can be made by either United States or state departments of agriculture.

The overall goals of noxious weed control activities are to limit the spread of such plants, reduce their numbers to a point where they cause no significant economic damage, and—where feasible—eradicate them. Control measures are conducted under authority of the Carson-Foley Act (PL 90-583) and the Federal Noxious Weed Act (PL 93-629). In recent years, acreages treated to control noxious weeds in the Pacific Northwest Region have ranged from approximately 3,000 to 10,000 acres per year.

On National Forest System lands, measures are taken to protect range values, wildlife habitat, and sensitive plant species, as well as to reduce the potential for spread of noxious weeds to other ownerships. Since noxious weeds fail to respect state, administrative, or property boundaries, close coordination among federal, state, and county agencies, and private land owners, is crucial to any effective program to control noxious weeds.

Control programs in the Pacific Northwest are conducted in cooperation with the Oregon Department of Agriculture, as well as individual counties or weed control districts in Washington State. The main distinction between the two states is that the Oregon Department of Agriculture has authority and responsibility for direct control measures, while in Washington, control activities are carried out by the counties, since the state has no such legal mandate.

The level of threat posed by various species of noxious weeds depends on such factors as the degree of detrimental effects they can produce, their reproductive and dispersal capabilities, difficulty of control, and overall distribution. Based on such considerations, particularly distribution and feasibility of control, the state of Oregon has developed a weed classification system. In Washington, a noxious weed list is developed at least yearly through a hearing process by the state noxious weed control boards.

Infestations of noxious weeds are located either through surveys, or incidental sightings by Forest Service personnel trained in their identification, or by Forest contractors and other Forest users. All infestations are considered undesirable, with the intensity and method of control depending on a variety of factors. These factors include: classification category, species biology, size of population, geographic location, potential for spread, other land characteristics or uses (such as presence of sensitive species, watershed values, health risks/threats), and budget considerations. General priorities for control

should be established at the Forest level through noxious weed management plans developed in coordination with the states and affected counties.

Methods

Herbicides

A variety of techniques have been used to apply chemicals to control noxious weeds including aerial (helicopter and fixed-wing), ground vehicles, and backpack sprayers. One potential chemical technique not yet fully developed is the use of species-specific herbicides that inhibit photosynthesis.

Mechanical

Various mechanical techniques can be used to prevent seed production by noxious weeds, reduce their vigor, and in some cases, eliminate them from a site. Mowing, cutting, or tilling may be appropriate depending on target species, associated vegetation, and terrain. In some woody species, cutting once every two years may be adequate to prevent flowering and seed production, while some herbaceous weeds may need to be mown two or more times per season. For species which can spread vigorously from root stocks, mowing may lead to increases in population.

Manual

Hand-pulling, digging and clipping have all been used to help control noxious weeds. Similar in many respects to mechanical techniques, these have generally been viewed as stop-gap measures to reduce seed production and generally not used to eliminate populations, except where very few plants are involved. Hand pulling and digging will be of limited effectiveness if care is not taken to remove all root material. Otherwise, resprouting is likely to occur.

Biological, Cultural, and Grazing Methods

Utilization of predators, pathogens, and parasites as natural enemies for the control of certain noxious weeds is the main emphasis of biological control methods. This is only possible because of the host specificity of these agents that is tied to their evolution in an ecosystem that naturally contains the host species. Since the majority of noxious weeds are introduced and are free of their natural enemies, these agents are attracted to their specific hosts.

The majority of cultural control methods used are seeding with grass/legume, forbs, and shrub species to provide competition to noxious weeds. This method is also used to prevent weeds from becoming established on a disturbed site.

Grazing of domestic livestock that are tolerant of the toxins produced by noxious weeds is used to control the composition or amount of the infestation.

Biological Methods

Biological control techniques involve the use of insects, mites, and pathogens (such as fungi). Basically, host-specific insects and pathogens are used to control plant numbers and vigor, reduce seed production, and limit spread. Especially when used in combination, such control agents may effectively eliminate noxious weeds from an area. However, their use is limited to areas where noxious weed densities are sufficient to allow the build-up of populations of the biological control agents.

Natural predators, pathogens, and parasites used in noxious weed control activities have a very low potential to adversely affect native plants or wildlife. The agents released for noxious weed control are species-specific and natural enemies of the weeds.

Before the agents are released for this purpose, the effects of using them are thoroughly studied and evaluated. Generally the process involves identifying the area and natural ecosystem that the plant has evolved in. Much of the research is conducted in Europe-Asia, where the plants are native species. The plant is monitored for natural enemies which help to control its growth and dispersal and these are examined for their species-specific preferences. If the agent appears to have a suitable application use, United States Department of Agriculture approval must be granted before entry into the United States is allowed. Since 1940, when biological control agents were first introduced for noxious weed control, no harm related to their introduction has been documented.

Collection and redistribution of insects increases effectiveness by supplementing natural rates of spread of the control agents. Several insects are currently in use for control of noxious weeds in the Northwest, and additional potential biological control agents are being tested. The Oregon Department of Agriculture has a listing of introduced noxious weeds, and the status of biological control agents (R. Brown, Oregon Department of Agriculture). Most of the information in the listing is also applicable to the State of Washington.

Presently, 21 species of noxious weeds have been targeted for control in the Pacific Northwest. Although it takes an average of three to five years for the biological control agents to become established at selected sites, their efficacy increases over time. While acres of land may be still considered to be "affected" by the noxious weed, the

agents have reduced infestations below economic injury and threshold levels.

Plants targeted for control are usually non-native, toxic to many wildlife species, or they compete with preferred forage plants. Wildlife species may, in some cases, actually slow the establishment of the biological control agent by utilizing them as a food source.

Seeding and Planting

Seeding of grasses, legumes, and forbs, or planting of shrubs depends on preparation of an adequate seedbed, which is exactly the reason they can be used as a competitor to the establishment of noxious weeds. Areas which have been treated by mechanical site preparation or prescribed burning, and heavy use areas at recreation sites, corrals, and trailheads (which leave areas of the soil exposed and disturbed) are susceptible to noxious weed invasion. Seeding is generally used in combination with other "preventive" techniques. Planting of desirable shrub species can be done in combination with manual techniques.

On transitory range (conifer plantations), these effects may last 10 to 20 years depending on conifer stocking levels and site productivity. Grass,legume, and forb seeding also increases the length of time that conifer plantations provide suitable foraging habitat for wildlife dependent on or preferring early seral stages.

Grazing of Domestic Livestock

Grazing activities that are properly timed and controlled have potential noxious weed control benefits. Grazing animals tolerant of the toxins produced by noxious weeds can be used in some cases to control weeds on a limited basis (for example, the use of sheep to consume tansy ragwort).

Prescribed Fire

Fire can be used to kill annual weeds, to reduce woody shrubs and other perennials, and in some cases, to prevent seed production. Burning has not been extensively used for control of noxious weeds since its use is restricted to areas where weeds are dense enough to make the technique practical, and where environmental considerations such as air quality are not limiting.

Table G-1. Noxious weeds and status of biological control agents introduced into the State of Oregon.

WEED	*SCIENTIFIC NAME*	*AGENT*	NICHE AND TAXA	YEAR INTRODUCED	# COUNTIES INTRODUCED	# COUNTIES ESTABLISHED	DISTRIBUTION	INFESTATION	CONTROL	COLLECTABILITY
Brown Knapweed	*Centaurea Jacea*	*Urophora quadrifasciata*	*Seed head fly*	1980s	3	1	L	L	U	L
Canada Thistle	*Cirslum arvense*	*Ceutorhynchus litura*	Crown weevil	1981	2	2	L	S	U	O
		Urophora cardul	Stem gall fly	1981	10	6	L	S	U	L
		Rhinocyllus conicus	Seed head weevil	1987	1	2	L	S	F	O
Dalmatian Toadflax	*Linaria dalmatica*	*Calophasia lunula*	Defoliating moth	1983	2	0	F	O	O	O
Diffuse Knapweed	*Centaurea diffusa*	*Urophora affinis*	Seed head fly	1975	STW*	STW	W	M	F	M
		Urophora quadrifasciata	Seed head fly	1975	STW	STW	W	H	M	M
		Sphenoptera jugoslavica	Root boring beetle	1980	8	2	L	M	U	L
		Pteroloncha Inspersa	Root boring moth	1986	1	0	U	O	O	O
Gorse	*Ulex europaeus*	*Aplon ullcus*	Seed weevil	1956	5	5	W	H	G	M
Italian thistle	*Carduus pycnocephalus*	*Rhinocyllus conicus*	Seed head weevil	1980	5	5	W	H	G	M
Leafy Spurge	*Euphorbia esula*	*Hylas euphorbiae*	Defoliating moth	1980	1	0	F	O	O	O
		Orberea erythrocephala	Stem boring beetle	1982	1	0	F	O	O	O
Meadow Knapweed	*Centaurea pratensis*	*Urophora quadrifasciata*	Seed head fly	1980	1	1	L	L	U	L
Mediterranean Sage	*Salvia aethiopis*	*Phrydluchus tau*	1972	3	2	W	M	P	M	
		Phrydluchus spilmani	Root weevil	1972	1	0	F	O	O	O
Milk Thistle	*Silybum marlanum*	*Rhinocyllus conicus*	Seed head weevil	1979	6	6	W	H	G	M
Musk Thistle	*Carduus nutans*	*Rhinocyllus conicus*	Seed head weevil	1979	3	3	W	H	G	M
Poison Hemlock	*Conium maculatum*	*Agonopterix alstroemariana*	Defoliating moth	1980	STW	STW	W	M	G	M
Puncturevine	*Tribulus terrestris*	*Microlarinus lareynil*	Seed weevil	1983	8	1	L	L	G	L
		Microlarinus lypriformis	Stem weevil	1983	8	1	L	L	G	L
Rush Skeletonweed	*Chondrilla juncea*	*Cystiphora schmidtl*	Stem gall midge	1978,87	1	1	L	L	U	O
		Aceria chondrillae	Gall mite	1978,87	1	1	L	L	U	O
		Puccinia chondrillina	Rust fungus	1978,87	1	1	L	L	U	O

WEED	SCIENTIFIC NAME	AGENT	NICHE AND TAXA	YEAR INTRODUCED	# COUNTIES INTRODUCED	# COUNTIES ESTABLISHED	DISTRIBUTION	INFESTATION	CONTROL	COLLECTABILITY
St. Johnswort	*Hypericum perforatum*	*Chrysolina quadrigemina*	Defoliating beetle	1948	STW	STW	W	H	E	M
		Chrysolina hyperici	Defoliating beetle	1980	2	2	U	U	U	O
		Agryllis hyperici	Root boring beetle	1986	1	U	U	U	U	O
		Zeuxidiplosis giardi	Seed head fly	1982	1	0	F	O	O	O
Scotch Broom	*Cytisus scoparius*	*Leucoptera spartifollella*	Twig mining moth	1970	10	10	W	L	U	L
		Aplon fuscirostra	Seed weevil	1983	6	2	L	L	F	L
Scotch Thistle	*Onopurdum acanthium*	*Rhinocyllus conicus*	Seed head weevil	1982,87	1	0	U	U	U	O
Slenderflowered Thistle	*Carduus tenulflorus*	*Rhinocyllus conicus*	Seed head weevil	1980	3	3	W	H	G	M
Spotted Knapweed	*Centaurea maculosa*	*Urophora affinis*	Seed head fly	1975	4	4	W	M	G	M
		Urophora quadrifasciata	Seed head fly	1975	4	4	W	H	G	M
		Matzneria paucipunctella	Root boring moth	1981,87	4	2	L	S	F	O
Tansy Ragwort	*Senecio jacobaese*	*Tyria jacobaese*	Defoliating moth	1960	18	17	W	H	E	M
		Hylemya senecialla	Seed head fly	1968	18	16	W	H	G	M
		Longitarsus jacobaese	Crown-root beetle	1971	18	16	W	H	E	M
Yellow Starthistle	*Centaurea solstitialis*	*Bangasternus orientalis*	Seed head weevil	1985,87	1	1	L	U	U	O
		Urophora sirunaseva	Seed head fly	1985	1	0	F	O	O	O
Yellow Toadflax	*Linaria vulgaris*	*Gymnaetron antirrhini*	Seed head weevil	1970	1	1	L	M	U	L
		Calophasia lunula	Defoliating moth	1983	1	0	F	O	O	O

KEY: DISTRIBUTION within host range: W - widespread, L - limited sites, F - failed to establish, U - unknown status.
INFESTATION of host: H - heavy >70%, M - medium >30%, L - light >10%, S - slight <10%, 0 - none detected, U - unknown status.
CONTROL ability on seeds and/or plant density: E - excellent, G - good, F - fair, P - poor, U - undetermined.
COLLECTABILITY for redistribution: M - mass collections, **L - limited collection, 0 - not collectable at present.

*Statewide within host range.

**Limited collectability indicates populations are slow in building or recently introduced. Work on these species should be coordinated through biological control specialists at the State Department of Agriculture. Transportation of biological control agents may require special permits and procedures.

Wildlife Habitat Improvement Activities

The principal objective of wildlife habitat improvement activities is to maintain an appropriate diversity, amount, and distribution of habitat in order to maintain viable populations of native wildlife, fish, and plants. Particular emphasis is placed on maintaining threatened, endangered, and sensitive species.

Habitat improvement is accomplished through coordination and mitigation procedures related to various resource activities and through direct habitat improvement projects. Primary direction for these objectives is found in the National Forest Management Act of 1976, and USDA Departmental Regulation 9500-4.

To a large degree, objectives for habitat management reflect population goals established in coordination with state fish and wildlife agencies. The Sikes Act of 1960 establishes the basis for cooperative relationships with the states regarding wildlife management.

Vegetation management activities are conducted to benefit a wide variety of wildlife species—from rare plants and butterflies to grizzly bears—but the majority of such activities are designed to provide improved forage and browse for elk and deer. Additionally, it is important to recognize the link of related habitat improvement activities such as water development with vegetation management activities. The development and distribution of water is often a primary component of forage improvement projects, especially for East-side Forests.

Methods

Herbicides

While the use of chemicals to control vegetation for wildlife habitat improvement has been very limited, opportunities for such manipulation exist. Shrubs can grow so tall and thick that they fail to provide useable browse. Herbicides, applied either from the air or the ground, can alleviate these problems in some cases. Similarly, herbicides have been used to restore forage productivity on elk range overrun by unpalatable weeds.

Mechanical

Various mechanical techniques are used to manipulate vegetation for

wildlife including chaining, cabling, crushing, and scalping. These techniques are most commonly used on brush to induce resprouting for improved browse and to reduce competition to favor herbaceous forage. Mowing has been used to control grasses to improve the growth of violets that are essential to the life cycle of the Oregon Silver Spot butterfly, a threatened species.

Manual

Manual techniques (such as cutting shrubs or trees encroaching on meadows) are used on a limited basis to control brush or other vegetation. Cutting is also prescribed to regenerate aspen stands. Pruning of trees and shrubs is used to improve production of fruits and berries.

Biological, Cultural, and Grazing

The use of insects as biological control agents against certain species of noxious weeds has been implemented within the Region. Noxious weeds can degrade valuable forage areas for wildlife use. Although the treatments are usually conducted for range improvement programs, wildlife species also benefit from the control efforts.

Seedings of grasses, legumes, forbs, and brush species are often used to improve ecological conditions and prevent damage by natural forces after site disturbances such as fire, logging, and construction projects. The seedings often improve the quality and quantity of available forage for wildlife. This is particularly the purpose when seeding is done immediately after a prescribed burn for wildlife habitat improvement. Other site disturbance projects that occur from road building, timber logging, watershed rehabilitation, range improvement, and recreation facilities construction may also use seedings (which have forage benefits for wildlife) to prevent soil, water, and wind erosion.

Grazing and browsing by domestic livestock has controlled shrubs and reduced unpalatable portions of herbaceous forage in some rangeland areas. An indirect benefit of this activity has been that new plant growth has been made available to wildlife. Although this technique has generally not been employed directly as a wildlife habitat improvement method, it could be used in some site-specific treatments.

Prescribed Fire

Fire is by far the most commonly used tool. Underburning in forested stands to improve forage is the most widespread use. Fire is also employed to control or rejuvenate brush, to maintain or create meadows and other openings, to remove slash impeding movement of big game animals, and as part of site preparation prior to planting forage.

Table G-2
Annual Wildlife and Fisheries Report:
Estimated Consumptive and Nonconsumptive
Wildlife and Fish User Days (WFUD's)
(Fiscal Year 1984)

Forest Name	Hunting	Fishing	Nonconsumptive	Total WFUD's
Colville	152,806	138,826	7,037	298,669
Deschutes	134,133	503,438	18,625	656,196
Fremont	51,786	92,010	2,483	146,279
Gifford Pinchot	286,752	464,926	64,967	816,645
Malheur	109,619	24,506	4,140	138,265
Mt. Baker-Snoqualmie	284,269	351,825	82,350	718,444
Mt. Hood	146,162	472,604	100,967	719,733
Ochoco	124,832	103,254	10,759	238,845
Okanogan	79,376	118,045	24,828	222,249
Olympic	69,183	74,523	1,656	145,362
Rogue River	34,191	80,956	434	115,581
Siskiyou	64,452	144,005	10,658	219,116
Siuslaw	86,490	259,140	19,447	365,077
Umatilla	1,100,093	36,050	26,254	1,489,398
Umpqua	87,839	287,718	10,347	385,904
Wallowa-Whitman	390,379	235,189	84,007	709,575
Wenatchee	418,063	538,600	72,002	1,028,665
Willamette	172,897	707,720	61,244	941,861
Winema	54,335	53,798	828	108,961
Subtotal WFUD's	3,847,657		4,450,690	

Total WFUD's, hunting and nonconsumptive uses: 8,298,347

(Note: a WFUD for hunting could be the equivalent of one person hunting for 12 hours, or 12 persons hunting for 1 hour. Use expressed in wildlife and fish user days (WFUD's) is determined from the best source of information available for wildlife- and fish- oriented recreation; whether from the recreation information management data base (RIM), from the states, or from other sources.

Table G-3
From 1984 Annual Wildlife and Fisheries Report
Regional Totals

	1983		1984	
Species	Population	Harvest	Population	Harvest
bighorn sheep (desert)	—	—	—	—
bighorn sheep (other)	582	9	585	10
bison	—	—	—	—
black bear	18,332	1,572	17,770	1,310
black-tailed deer	222,133	18,038	210,675	17,641
caribou	6	0	6	0
Dall sheep	—	—	—	—
elk, Rocky Mountain	69,595	15,019	63,622	12,941
elk, Roosevelt	29,494	3,166	28,993	2,831
grizzly bear	4	0	4	0
moose	45	0	49	0
mountain goat	4,471	198	4,097	224
mountain lion	1,867	120	1,928	107
mule deer	217,570	25,123	190,465	22,574
pronghorn antelope	2,080	125	2,160	126
turkey	1,849	38	2,353	25
white-tailed deer	15,665	2,095	16,040	2,093
wild boar	—	—	—	—
wolf	2	0	2	0

Recreation Maintenance

The basic mission of this program is to provide outdoor recreation opportunities for the Nation. The objectives for publicly managed recreation opportunities, which include developed recreation sites, are:

1) to maximize opportunities for visitors to know and experience nature while engaging in outdoor recreation;

2) to develop and manage sites consistent with the available natural resources to provide a safe, healthful, esthetic, nonurban atmosphere; and

3) to provide a maximum contrast with urbanization at National Forest sites.

Forest recreation opportunities are classed as developed recreation, dispersed recreation areas, or special interest areas. Developed recreation refers to specific sites where facilities have been provided such as campgrounds, picnic areas, boat docks, or ski lifts. These sites are generally easily accessible and designed to provide a modern recreation experience in a natural setting. Dispersed recreation describes the use of lands and water bodies throughout the National Forests where recreation opportunities such as backpacking, hunting, nature studies, primitive camping, or cross-country skiing are available. Minimal improvements such as parking and sanitation facilities at trailheads are provided for dispersed uses. Special interest areas are generally unimproved and have been designated for a specific value such as a geologic, scenic, historic, or botanical interest area.

Within the Pacific Northwest Region there are over 1,900 developed recreation sites including permittee operations and privately owned sites within National Forest boundaries.

Vegetation management is part of the operation and maintenance of developed recreation sites. Vegetation management is used to provide for public safety, reduce fire hazards, improve visibility and access, and to control poisonous plants.

Forest Service Manual direction requires that a vegetation management prescription be prepared for each recreation site. The primary objective of the prescription is to create and maintain a natural-looking environment.

In general, these prescriptions call for trimming and removal of

grass, brush, or trees to allow the site to be used safely, while retaining over-story and understory cover. This includes trimming or removing vegetation along site access roads for adequate sight distance, around signs and other facilities, and in individual camp or picnic sites. Where necessary, direction is given for control of poison oak or other toxic plants. Hazard trees are removed when necessary. Vegetation surrounding (or interspersed among facilities within) sites is retained for a natural appearance. Brush removal is also prescribed to maintain cleared ski runs.

Developed sites are inspected annually to note any deficiencies, including safety hazards and vegetation treatment needs. Such inspections are documented in Ranger District records, which contain base data used to develop annual site operation and maintenance plans.

Techniques presently used in developed recreation sites are primarily manual and mechanical. In campgrounds and picnic areas, hand-held implements such as brush hooks, scythes, saws, and "weedeaters" are used to trim brush, and mowing machines may be used on roadside strips. Brush is either scattered or hand-piled, or piled by small tractors, and removed, burned, or chipped. When tree removal is necessary, the technique causing the least impact to the environment is used for yarding and brush disposal.

Tractors, along with manual methods, are used for brush removal and disposal to maintain cleared ski runs.

Facilities Maintenance

A facility is a single or contiguous group of improvements that exists to shelter or to support Forest Service programs. A facility may be a ranger station compound, lookout tower, leased office, work center, separate housing area, visitor center, or research laboratory. There are approximately 200 of these sites in the Pacific Northwest Region.

Facilities are managed to provide cost-effective, safe, functionally-efficient buildings and related improvements for conducting the work of the Forest Service. Vegetation management is performed to provide safe working conditions, provide for protection of materials and property, and to provide an aesthetically pleasing appearance for the facility.

Each administrative site has a site development plan that includes a landscape management plan or planting plan. The landscape

management plan delineates the areas where vegetation will be maintained or controlled, and prescribes appropriate treatments, including manual, mechanical, and chemical methods. Chemical methods at this time are limited to fertilizers and pesticides that are used on lawns and shrubs to enhance growth.

Rights-of-Way Maintenance

Rights-of-way maintenance includes controlling vegetation along (and within) highways and roads, land lines, trails, utility corridors, and railroads. Historically, vegetation control programs for rights-of-way maintenance have included the full range of options - manual, mechanical, biological, thermal, and chemical.

USDA-Forest Service Roads

Forest roads are of primary importance for the protection, administration, and utilization of the National Forests and other areas administered by the Forest Service, or for use and development of resources upon which adjacent communities are dependent.

The National Forest Management Act of 1976 requires that "roads constructed on National Forest System lands shall be designed to standards appropriate for the intended uses, considering safety, cost of transportation, and impacts on land and resources." Roadside vegetation management is used to protect this investment and provide safety for the users in concert with the roads intended use. (National Forest Management Act, Section 8 (c).)

Current maintenance standards for Forest roads are defined in Forest Service Handbook 7709.15. Maintenance Levels 1 through 5 determine the intensity of maintenance, including roadside vegetation management. Maintenance Level 1 does not require vegetation management except as necessary to protect the investment. Maintenance Level 2 requires brushing to provide passage for high clearance traffic. Maintenance Level 3 requires brush control to provide for safe sight distance. Maintenance Levels 4 and 5 require brush control to be accomplished on a scheduled basis for safe sight distance and for appearance. Approximately 29 percent of the total road system is in Maintenance Levels 3 through 5, and the remainder is in Maintenance Levels 1 and 2.

Forests currently use these standards in conjunction with established road logs, condition surveys, Road Management Objectives, and periodic maintenance plans to determine when, where,

and how vegetation management will take place on Forest Service roads. Economics, environmental considerations, the current restriction on herbicide use in the Pacific Northwest Region, and public concerns all have an influence on the method of vegetation management selected. Line Officers at the Forest level (District Rangers or Forest Supervisors) generally make the final decision as to what method will be used.

The following methods have been used in the past with varying degrees of success:

1. Manual techniques have received limited use, but are effective in certain instances. These are used mainly on the inside of curves where mechanical mowers will not reach, in areas where brush is sporadic and it is not cost-effective to run a mechanical mower down a road, and for doing hand pulling or grubbing of certain target species.

2. Biological methods are mostly confined to planting and fertilization of grasses. Biological methods have been considered experimental in the past, but are gaining favor as a preventive measure rather than a curative treatment.

3. Mechanical techniques, used extensively by the Forest Service, are effective treatment methods. Mechanical brushing is performed with tractor-mounted flail-type mowers, rotary-type mowers, or sickle bars. However, with fast growing target species, mowing must be done periodically; but this usually increases the density of resprouting of these species, adding to the overall problem. Forest Service personnel who perform this work are licensed equipment operators.

4. Thermal techniques are seldom used. Piling and burning of right-of-way brush is occasionally used but has a high cost. Backpack flame throwers have been used on a very limited basis to control vegetation adjacent to asphalt pavements.

5. Chemical methods are effective when used properly. However, rising social and environmental costs (along with the current injunction on using herbicides) have given rise to using less chemical treatments and exploration of other nonchemical alternatives. Before the injunction, herbicides were generally applied along roadsides using backpacks, mobile booms, or hand wands. All Forest Service applicators were licensed by the States (Oregon or Washington) where the roads are located.

From a practical standpoint, methods 1,2,3, and 5 above are all viable options. There are approximately 87,900 miles of Forest Service roads in the Pacific Northwest Region. Conditions range from very dry on the East-side of the Cascades (where little roadside brushing is required) to very wet on the Coast (where heavy, dense, fast-growing brush is common).

In addition to controlling vegetation along rights-of-way for maintenance, it is also necessary to manage unwanted vegetation along newly constructed roads. The Pacific Northwest Region constructs approximately 600 miles of road each year. Options for disposal of clearing debris include windrowing, scattering, burying, chipping, piling and burning, disposal in cutting units, removal, piling, and placing on embankment slopes.

Highways

Highways affected by the Forest Service vegetation management program include the public vehicle transportation system of the Department of Transportation for Oregon and Washington; other Federal agencies such as Bureau of Land Management; and specific counties in Oregon, Washington, and California.

Vegetation management along those routes is designed to meet responsible agency maintenance objectives. These include:

- perpetuating the transportation facility to serve its intended purpose;
- protecting the investment;
- protecting the environment;
- providing for user safety, economy, access, and convenience; and
- meeting all applicable air and water quality standards.

Public vehicle transportation system agencies maintain approximately 4,300 miles of highways within the National Forests of Oregon and Washington. Historically, vegetation along these roads has been controlled using manual, mechanical, biological, and chemical methods.

Utility Corridors

A number of public and private utilities have rights-of-way through the Region's National Forests. Power line utilities have above-ground and buried cable line rights-of-way and access roads, along with substation property and power plant sites. These utilities maintain

approximately 25,800 acres on National Forest land.

Communication utilities have transmission rights-of-way, access roads, wave guide routes, communication towers, and exchange (relay) stations. The 50-plus communication network utilities annually maintain approximately 1,500 acres on National Forest land.

There are also a number of agencies and private utilities with permits allowing the transport of water in open channels or pipes for use in farm irrigation or at electrical power plants. There are 493 waterway permits involving approximately 1,000 acres of rights-of-way. About 25 percent of the total is ditches.

Vegetation control programs are used to keep trees and other tall vegetation from growing into conductors, thus preventing power outages and possible forest fires. Vegetation is also managed along access roads and along waterways (irrigation ditches) to control aquatic and noxious weeds.

Manual, mechanical, and chemical methods are all used to control vegetation. In metropolitan and urban areas mechanical and manual methods are the primary treatment for vegetative control due to ease of access. In forest areas the lack of access for mechanical equipment often results in a strong preference for chemical treatment.

Over 90 percent of the waterway treatment is by manual or mechanical methods.

Railroads

Railroad transportation systems have rights-of-way, access roads, crossings, and communication lines (including towers) throughout National Forest lands in Oregon and Washington. These areas require annual vegetation control to prevent train-caused fires; to maintain the roadbed and eliminate safety and nuisance problems for railroad personnel; to maintain ditches and other drainage structures; and to provide visibility at railroad crossings.

Annually, railroads (there are 17 permits) use manual, mechanical, and chemical methods to control vegetation on roadbeds and fire breaks along 105 miles of right-of-way.

Trails

Throughout the Pacific Northwest Region of the Forest Service there are approximately 15,000 miles of established trails. Vegetation along these trails is controlled to protect the investment, to reduce poisonous plants, and to eliminate branches and stems for user safety.

Annually, the Region performs vegetation management on approximately 3,200 miles of trail. Vegetation is cleared within four to eight feet of the trail tread, depending on the trail standard.

Nearly all vegetation management along trails is accomplished using manual methods. Approximately 1 percent of the total vegetation control effort has utilized chemical treatments in the past.

Land Line Location

Land Line Location is a Forest Service land surveying program that identifies, marks, posts, and maintains legal property lines and administrative boundaries where property rights and/or management activities require accurate field delineation because of a legal requirement (Forest Service Manual 7151.06 6.).

Except for lines posted for subdued visibility and areas where vegetation regrowth will quickly obscure the line, the property line is to be cleared of small trees, brush, and debris for a distance of about two feet on each side of the line. When an offset method of survey is used, only the property corners are posted and cleared. Hand methods (for example, power saws or machetes) are almost always used.

Maintenance is performed on a periodic basis. The maintenance interval is dependent on local conditions but should never exceed ten years.

There are approximately 12,000 miles of lines that have been located and established by an acceptable official survey and should be periodically maintained. An estimated 150 miles of land line was maintained in 1987.

The Genetics Program

Background

The demand for a diversity of forest products is increasing, yet the land base for producing timber products is decreasing. Thus, there is a need to improve productivity on the remaining acres. The genetics program was developed as an integrated Regional strategy to fill this need in both the long and short run.

The program reaches out through cooperators to lands managed by other public agencies and private land holders, as a further measure to assure a continued flow of timber products.

The Region spends approximately $7 million annually on genetics and related activities. There are 252 seed orchards and 262 evaluation plantations totaling 5,298 acres. A number of superior parent trees

have been selected and are being continually evaluated. All the Region's National Forests have geneticists or persons with appropriate expertise who administer the program locally. A local tree improvement plan provides guidance and coordination with Regional goals.

Purpose and Objectives

The purpose of the genetics program is to increase yields of high quality forest products. Individual trees that exhibit specific outward characteristics are selected as parent trees to provide seed for future generations or crops.

Three characteristics or traits are of concern: 1) rapid growth with high quality wood; 2) resistance to insects and disease; 3) site specific adaptation; or some combination of the three. For example, an individual sugar pine tree may be selected as a parent because it is resistant to blister rust and has a rapid diameter growth rate. The intent is to capture the genetic material responsible for controlling the desired traits.

Implementation

District and Forest personnel are responsible for the implementation of the program. Area geneticists coordinate among several Forests. Most activities are centered around parent tree selection, installing and maintaining evaluation plantations, and operating seed orchards. Vegetation management activities are applied to enhance seed production and tree vigor, facilitate operations, and to reduce fire hazard and animal damage. Survival and unimpaired early growth are also essential. A uniform environment around each parent tree is necessary to minimize the effects of the environment and maximize the expression of its heredity. Evaluation of the parent tree is most reliable under these conditions.

Site-Specific Considerations

The intensity of vegetation control is dependent on site factors such as slope steepness and aspect, and soil variation including erodibility, infiltration rate, and chemical composition. Site degradation is not tolerated.

Research Program

The objective of the research program is to develop knowledge and technology for the enhancement of the economic and environmental values of Forest and rangeland. The program seeks better ways to use

Forest and rangeland resources by developing technology to reduce costs, increase productivity, and protect environmental quality.

Projects involve biologists, economists, engineers, social scientists, and those in other disciplines, often in cooperation with universities, State agricultural experiment stations, other U.S. agencies, and foreign countries.

The knowledge is used by the National Forest System at all levels to assist in setting policy and to provide information for site-specific projects and long-term planning.

Background

Forest Service research is authorized under the Forest and Rangeland Renewable Resources Research Act of 1978 (92 Stat. 353). This act complements the policies and direction set forth in the Forest and Rangeland Renewable Resources Act of 1974 (16 U.S.C. 1641) directing the Forest Service to obtain, analyze, develop, demonstrate, and disseminate scientific information about protecting, managing, and utilizing forest and rangeland renewable resources.

The Pacific Northwest station operates ten field laboratories located in Alaska, Oregon, and Washington. It employs approximately 350 people (about one-third are scientists) with an annual budget of approximately $16 million. An additional $4 million helps to fund cooperative projects with agencies, universities, and private corporations from around the country.

Implementation

Research projects are commonly based on National Forest System needs. There are a significant number of projects that deal with vegetation management techniques, concepts, and environmental effects. Information needs on vegetation management techniques and effects have been increasing, thus there is a concurrent need for a full array of vegetation management research.

In cases where vegetation management is the subject of study, levels of control are determined by the study design and the specific objectives of the study. However, vegetation management is often needed to maintain research plots. Corners, markers, and access need to be clearly visible and functional and control measures applied accordingly.

Appendix J

Wildlife Use of Six Broad Forest Types

J

Appendix J

Herbicide Review With Wildlife-Oriented Effects

Table of Contents

J Wildlife Use of Six Broad Forest Types

This chart shows the six broad forest types, their natural vegetation characteristics, and typical treatments/methods as discussed in Appendix A. The wildlife species listed display:

1) species commonly found within Oregon and Washington;

2) species whose feeding habits use grass/forb stand conditions as either primary or secondary habitat within the six broad forest types.

The species and habitat use is based upon the information contained in Management of Wildlife and Fish Habitats in Forests of Western Oregon and Washington (Brown, 1985). The information is modified to allow for combinations of plant communites to develop the broad forest types.

While other habitat components and site-specific conditions limit the actual distribution of these species, if the species are known to occur in the general vicinity of the treatment area, it is reasonable to assume their use of the grass/forb stand condition.

Full Yield Timber Acres

Natural Vegetation Characteristics

Typical vegetation treatments

Typical vegetation treatment methods (modified by site-specific requirements)

Typical Wildlife Species using Area (grass/forb stand condition)

A	B	C
Douglas-fir/alder	**Douglas-fir/hemlock/ salmonberry/herbaceous**	**Douglas-fir/ponderosa pine/ ceanothus/herbaceous**
236,800	195,100	1,436,200
Alder dominates Douglas-fir in 25 years.	Salmonberry and its associates aggressively reoccupy disturbed sites within several years.	Relatively low site quality. Shrub species often important components. Intense grass and weed competition. Soil moisture limitations
a) Site preparation after logging b) Conifer release at 5-6 years.	a) Site preparation after logging b) Release at 2-3 years	a) Site preparation after logging b) Vegetation control within 5 years
a) Mechanical slash piling a) Slash burning	a) Broadcast burn a) Herbicide	a) Broadcast burn a) Herbicide, manual weeding, grubbing, forced grazing of cattle
b) Herbicide b) Manual release cutting of alder	b) Herbicide b) Manual release cutting of brush	b) Herbicide, cattle grazing b) Manual scalping
See next page	See next page	See next page
(1) = Primary Habitat (2) = Secondary Habitat	(1) = Primary Habitat (2) = Secondary Habitat	(1) = Primary Habitat (2) = Secondary Habitat

D	E	F
Douglas-fir/ponderosa pine/ ceanothus/herbaceous	**Douglas-fir/tanoak/madrone**	**True fir/hemlock/shrub/ grass/herbaceous**
912,600	169,300	1,474,700
Snowbrush and deerbrush aggressive sprouters after disturbances. Soil moisture limitations.	Summer drought and limited moisture holding capacity. Aggressive herb and shrub competition within 3 years. Skeletal soils.	Once established conifers can maintain growth response. Higher elevation stands.
a) Site preparation after logging b) Vegetation control within 4 years	a) Site preparation after logging b) Vegetation control within 5-7 years	a) Site preparation after logging b) Vegetation control within 3 years
a) Herbicide, manual, mechanical	a) Herbicide	a) Herbicide
b) Herbicide, manual, mechanical	b) Herbicide, "hack and squirt" and injections; manual 1.5 to 3 treatments	b) Herbicide, mechanical, burning b) Manual scalping
See next page (1) = Primary Habitat (2) = Secondary Habitat	See next page (1) = Primary Habitat (2) = Secondary Habitat	See next page (1) = Primary Habitat (2) = Secondary Habitat

	A	B	C	D	E	F
Amphibians						
1. clouded salamander	2*	-	2	-	-	-
2. ensatina roughskin	-	-	2	-	2	-
3. newt	1	1	1	2	2	2
4. western toad	1	1	1	2	1	1
5. Pacific tree frog	1	1	1	2	1	1
6. red-legged frog	2	2	2	2	2	2
7. foothill yellow-legged frog	2	2	2	-	2	-
Reptiles						
8. painted turtle	-	1	1	-	1	-
9. western pond turtle	1	1	1	-	1	2
10. northern alligator lizard	1	1	1	2	1	1
11 southern alligator lizard	2	-	2	-	1	-
12. sagebrush lizard	2	-	-	-	-	2
13. western fence lizard	1	1	1	-	1	2
14. western skink	1	1	1	-	1	2
15. western terrestrial garter snake	1	2	1	1	1	-
16. northwestern garter snake	1	1	2	2	2	-
17. common garter snake	2	2	1	2	1	2
Birds						
18. turkey vulture	1	2	1	1	2	2
19. sharp-shinned hawk	2	-	2	2	2	-
20. Cooper's hawk	2	2	2	-	2	2
21. red-tailed hawk	1	1	1	1	1	1
22. golden eagle	2	1	2	1	2	2
23. American kestrel	2	1	2	2	1	1
24. merlin	2	2	2	2	2	2
25. peregrine falcon	2	2	2	2	2	2
26. prairie falcon	2	-	-	-	1	-
27. ring-necked pheasant	2	2	2	2	2	-
28. blue grouse	2	1	2	2	2	1
29. ruffed grouse	2	2	1	2	1	-
30. wild turkey	1	-	-	1	1	-
31. California quail	-	-	-	1	1	-
32. mountain quail	1	1	2	1	1	2
33. band-tailed pigeon	2	2	2	2	2	2
34. mourning dove	1	2	1	-	1	-
35. barn owl	1	1	1	1	1	-
36. western screech owl	2	2	2	2	2	2
37. great horned owl	1	1	1	1	1	1
38. northern pygmy owl	2	2	2	2	2	2
39. long-earred owl	1	1	1	-	1	1
40. northern saw-whet owl	1	1	1	1	1	1
41. common night hawk	1	1	1	1	1	1
42. Vaux's swift	1	1	1	1	1	1
43. rufous hummingbird	1	1	1	-	1	1
44. Lewis' woodpecker	2	-	2	2	2	-
45. northern flicker	1	1	1	1	1	1
46. pileated woodpecker	2	2	-	-	-	2

	A	B	C	D	E	F
47. Say's phoebe	2	2	2	2	2	-
48. purple martin	2	2	2	-	2	-
49. tree swallow	1	1	2	-	1	2
50. violet-green swallow	1	2	2	2	1	2
51. cliff swallow	2	2	2	-	1	-
52. barn swallow	2	2	2	2	1	2
53. scrub jay	2	-	2	2	2	-
54. American crow	2	2	2	2	1	2
55. common raven	1	1	1	1	1	1
56. western bluebird	1	-	1	-	1	-
57. mountain bluebird	2	-	-	-	2	2
58. Townsend's solitare	2	2	2	2	2	2
59. American robin	1	1	1	1	1	1
60. northern shrike	2	2	2	2	2	-
61. European starling	1	2	1	1	1	-
62. lazuli bunting	2	-	2	-	1	-
63. rufous-sided towhee	2	2	2	2	2	-
64. chipping sparrow	1	1	1	1	1	2
65. fox sparrow	2	2	2	-	2	-
66. song sparrow	1	2	1	-	1	-
67. Lincoln's sparrow	2	2	2	2	2	2
68. golden-crowned sparrow	2	2	-	-	2	2
69. white-crowned sparrow	2	1	2	-	2	2
70. dark-eyed junco	1	1	1	1	1	1
71. western meadowlark	2	-	2	2	2	-
72. Brewer's blackbird	1	1	1	1	1	2
73. brown-headed cowbird	1	2	1	1	1	2
74. purple finch	2	2	2	2	2	-
75. Cassin's finch	2	-	2	-	-	2
76. house finch	-	-	1	2	1	-
77. pine siskin	1	1	2	-	2	1
78. American goldfinch	-	2	2	-	1	-
Mammals						
79. Virginia opossum	1	2	1	1	1	-
80. Pacific water shrew	-	2	2	-	-	2
81. dusky shrew	-	2	-	-	-	2
82. Pacific shrew	2	2	-	-	-	2
83. vagrant shrew	1	1	2	1	2	1
84. shrew mole	2	2	-	2	-	2
85. broad-footed mole	1	1	2	2	2	1
86. Townsend's mole	2	1	2	-	-	2
87. big brown bat	1	1	1	1	1	1
88. silver-haired bat	2	2	2	2	2	2
89. California myotis	2	1	1	1	1	1
90. little brown myotis	1	1	1	1	1	1
91. fringed myotis	1	1	1	1	1	1
92. long-legged myotis	2	2	2	2	2	2
93. Brazilian free-tailed bat	1	-	1	1	1	-
94. coyote	1	1	1	1	1	1
95. gray fox	2	2	2	2	2	-

	A	B	C	D	E	F
96. red fox	1	1	1	-	1	2
97. black bear	1	1	2	1	2	1
98. raccoon	1	1	1	1	1	2
99. river otter	2	2	2	-	2	2
100. striped skunk	2	2	2	1	1	-
101. ermine	1	1	1	2	2	1
102. long-tailed weasel	1	1	2	2	2	1
103. mink	2	2	2	2	2	2
104. spotted skunk	2	2	2	2	2	2
105. badger	2	2	2	2	2	-
106. mountain lion	2	2	2	2	2	2
107. bobcat	1	1	2	2	2	1
108. elk	1	1	1	1	1	1
109. mule deer & black-tailed deer	1	1	1	2	2	1
110. mountain beaver	2	2	2	-	-	2
111. yellow-bellied marmot	-	-	-	-	-	1
112. California ground squirrel	1	1	1	1	1	2
113. golden-mantled ground squirrel	2	2	-	-	-	2
114. yellow pine chipmunk	-	-	-	-	-	2
115. Siskiyou chipmunk	2	-	2	-	-	-
116. Townsend's chipmunk	-	2	2	2	2	2
117. western pocket gopher	2	1	1	1	1	1
118. bushy-tailed woodrat	2	2	2	2	2	2
119. deer mouse	2	2	2	2	2	2
120. long-tailed vole	2	1	-	-	-	2
121. creeping vole	1	1	1	-	1	1
122. Townsend's vole	2	1	2	2	2	2
123. western jumping mouse	1	-	-	2	-	1
124. Pacific jumping mouse	-	1	1	2	1	1
125. porcupine	1	1	1	-	-	2
126. pika	-	-	-	-	-	1
127. snowshoe hare	1	1	-	2	-	1
128. black-tailed jack rabbit	-	-	2	-	2	-
129. brush rabbit	1	1	1	-	1	1

TOTALS	A	B	C	D	E	F
Amphibians - 7						
(1) Primary Habitat	3	3	3	0	2	2
(2) Secondary Habitat	3	2	4	4	4	2
Reptiles - 10						
(1) Primary Habitat	6	6	7	1	8	1
(2) Secondary Habitat	3	2	2	3	1	5
Birds - 61						
(1) Primary Habitat	25	21	22	19	33	14
(2) Secondary Habitat	33	28	33	23	26	23
Mammals - 51						
(1) Primary Habitat	22	25	18	14	16	21
(2) Secondary Habitat	21	19	23	20	20	23
	116	106	112	84	110	91

Herbicide Review With Wildlife-Oriented Effects

This information is a synopsis of information provided by:

Handbook of Weed and Insect Control Chemicals for Forest Resource Managers, Michael Newton and Fred Knight, Timber Press, Beaverton, Oregon, 1981.

Herbicide Handbook of the Weed Science Society of America, Fifth Edition, 1983.

Pesticide Background Statements (PBS), USDA Forest Service, Agricultural Handbook No. 633, August 1984.

Pesticide Fact Sheets, Northwest Coalition for Alternatives to Pesticides, Eugene, Oregon, authored by Mary O'Brien: Amitrole, April 1987; Asulam, July 1987; Atrazine, November 1986; 2,4-D, October 1986; Picloram, January 1987; Roundup, September 1987; Triclopyr, June 1987.

Amitrole

Amitrole Non-selective for conifer release, general weed control, and range improvement

Trade names: Cytrol Amitrol-T, Amizol, Weedazol

Special Problems: Ingredient, ammonium thiocyanate, has acute oral toxicity to rats, fish, and amphibians. It is persistent in water-bearing ditches for 20 + days; unusually persistent in groundwater.

Studies:	Dietary:	Japanese quail, ring-necked pheasants, mallards.
	Injection:	white leghorn chicks, chicken eggs .

LC (Lethal Concentration) is 50 > 10 ppm for freshwater, marine, and terrestrial invertebrates

LD (Lethal Dose) is 50 > 2000 mg/kg body weight for various species of birds.

Dermal LD is 50 (Amizol) 10,000 mg/kg in rabbits.

In subchronic toxicity studies in rodents, the thyroid gland was affected (goiter formation was induced).

(PBS): It has already been pointed out that ammonium thiocyanate (an ingredient in many amitrole formulations) has an acute oral toxicity to rats that is considerably greater than that of amitrole alone. (Weed Science Society of America, 1983). In fish and amphibians a number of sublethal effects have been observed.

(PBS): Dietary studies with amitrole indicate a low toxicity to birds. Japanese quail, ring-necked pheasants, and mallard ducks ingested as much as 5000 ppm amitrole in their diet for five days without mortality. The acute oral LD50 for young male mallards (three to four months old) was determined by Tucker and Crabtree to be in excess of 2,000 mg/kg body weight. In this latter study, the birds were observed to exhibit loss of coordination, a slight wing drop, and weakness for the first three days after the acute dose. Mallards fed amitrole in doses 25 percent less than those that would normally lead to mortality suffered depressed reproduction. When white leghorn chicks, 3 to 38 days old, were injected intraperitoneally with amitrole at doses as high as 1,000 mg/kg body weight, they displayed a reduced rate of weight gain and changes in the microanatomy of the thyroid gland. Amitrole injected into embryonated chicken eggs at 100 ppm resulted in toxic effects. Landauer et al found dose-dependent abnormalities (primarily malformed beaks) in chicken embryos when the 96-hour embryonated eggs were injected with 10 mg amitrole per egg.

(PBS): No studies have been conducted on wildlife in the field.

Subchronic: Amitrole has a very low acute toxicity to upland game birds. Avian (mallard duck and ring-necked pheasant) acute LC 50 testing produced values greater than 5,000 ppm, suggesting that amitrole is practically non-toxic to birds.

Formulated product: Little or no acute hazard to birds or aquatic organisms is expected for terrestrial uses of amitrole. The acute studies (freshwater fish, invertebrates, and birds) suggest that amitrole is practically non-toxic to non-target organisms.

Data gaps: Single-dose oral LD50 testing was performed on one avian species. In order to establish the acute toxicity of amitrole to birds, the following tests are required on the technical: two subacute dietary studies on one species of waterfowl and one species of upland game bird.

Results from the two dietary studies on ring-necked pheasant and mallard duck suggest that amitrole is practically non-toxic to birds. The calculated dietary LC50 values were greater than 5,000 ppm for each species of bird. These tests are scientifically sound, and will support registration.

(PBS): Amitrole is a non-selective herbicide for use in conifer release, general weed control, and range improvement.

The herbicide works by affecting a variety of biochemical processes. LC50 is greater than10 ppm for freshwater, marine, terrestrial invertebrates. Acute oral toxicity for fish ranges from LC50 of 10 ppm (amitrole) to 10,000 ppm (Cytrol Amitrol-T). LD50 is greater than 2,000 mg/kg body weight for various species of birds. Dermal LD50 for Amizol was 10,000 mg/kg in rabbits. Subchronic toxicity: amitrole affects primarily the thyroid gland resulting in adenomatous changes, hyperplasia, or goiter formation in rodents. It is a weak mutagen; it did appear to damage DNA (mammalian cells in vitro). It is not teratogenic in rats. High doses fed to parents (500-1,000 ppm) resulted in pups that were runted and had atrophic thymuses and spleens. Hyperplasia of the thyroid was observed in all animals fed 100 ppm amitrole or greater. Amitrole is carcinogenic in animals, and is readily metabolized, absorbed, and eliminated primarily in urine. It does not appear to bioaccumulate. Low exposure hazard: toxicity increases when formulation includes ammonium thiocyanate (to increase its systemic action). In rats acute oral LD50 of ammonium thiocyanate is 750 mg/kg body weight vs. 25,000 mg/kg amitrole.

Asulam

Asulam (Methylsulfanilyl carbamate) is a general herbicide used for the control of herbs and woody species, and in limited circumstances has some selectivity for conifers. It has important herbicidal effects on bracken fern almost exclusively.

Trade names: Asulox

Special Problems: Asulox was registered for use in the United states in 1975, but little information has been produced on its environmental fate and effects on wildlife. 62% of asulox formulation is unrevealed chemicals.

Studies: Bobwhite quail.

Acute Oral LD 50 > 2600 mg/kg for partridge.

Acute Oral LD 50 > 4000 mg/kg for mallard, pheasant, and pigeon.

(PBS): Asulam has a low order of toxicity to birds. Bobwhite fed Asulam at levels up to 25 ppm for 28 days were not affected with respect to food consumption rate, growth rate (body weight), or cumulative mortality. No effects were observed on egg production, fertility, or hatchability, or on incidence of congenital malformations (Gallo et al. 1975). (PBS): acute oral LD50 is greater than 2,600 mg/kg

for partridge, and greater than 4,000 mg/kg for mallard, pheasant, and pigeon (WSSA 1983).

Atrazine

Atrazine Atrazine is a selective herbicide used in conifer release, site preparation, grass and noxious weed control, wildlife habitat improvement, and rights-of-way use.

Trade Names:	Atrazine 80W
	Aatrex 80
	Atrazine 90

Special Problems: atrazine has been used widely in the United States since 1958. It is toxic to non-target plant species and is moderately persistent in soil. It is one of the most common pesticide contaminants of groundwater; it is toxic to some aquatic organisms at $\leq$10 ppm. Atrazine has a low tendency to bioaccumulated and is toxic to highly toxic to fry of most species of fish. Wisconsin leopard frog surveys show decline in populations in contaminated water with atrazine, and tadpoles' growth was retarded at 0.31 mg/l. It is practically non-toxic to birds, but one study showed increased hatchability of chicks from hens fed an intermediate dose.

LD 50'S are listed as 3,000 mg/kg in rats and1,750mg/kg in mice. 30 mg/kg is embrytoxic and fatal to pregnant and non-pregnant ewes.

(PBS): (Atrazine-17): In several long-term feeding studies in chickens, pheasants, etc. there were mostly no observed effects, but one study showed increased hatchability of chicks of hens fed an intermediate dose. No studies were available on wild mammals. (Atrazine-25): atrazine has a low tendency to bioaccumulate in animals. Once absorbed, it is rapidly metabolized to nontoxic metabolites that are readily excreted via the kidneys.

There are even subacute dietary toxicity data for use in hazard assessment. There is sufficient information to characterize atrazine on a dietary basis as practically non-toxic to birds. The avian subacute dietary guideline requirements have been satisfied by the evaluated documents.

There are three acceptable acute oral toxicity data for use in hazard assessment. There is sufficient information to characterize atrazine on an acute oral basis as slightly to practically non-toxic to birds. The avian acute oral guideline requirements have been satisfied by the evaluated documents.

(PBS): Atrazine is selective for conifer release, site preparation, grass and noxious weed control, wildlife habitat improvement, and rights-of-way. It is toxic to non-target plant species; persistent to moderately persistent in soil, and moderately persistent in water. The herbicide works as a photosynthetic inhibitor. It is toxic to some aquatic organisms at <10 ppm. Data indicate a very low toxicity to birds. LD50 is 3,000mg/kg in rats and 1,750 mg/kg in mice. It is absorbed primarily by plant roots and translocated to all above ground parts of the plant. Atrazine has a low tendency to bioaccumulate in animals. It is metabolized and excreted via the kidneys. Atrazine is moderately persistent in the soil and only slightly soluble in water.

In fish and amphibians, teratogenic effects have been at doses of 5-25 ppm atrazine. In aquatic invertebrates, toxic effects generally appear at concentrations below 10ppm and for some species, below 1 ppm. It is acutely toxic to aquatic invertebrates such as clams, caddisfly larvae, and mayfly nymphs. Atrazine should be considered toxic to highly toxic to fry of most species of fish and slightly toxic to toxic for adults of most species of fish. Atrazine is toxic to slightly toxic to amphibian eggs and tadpoles. It induces teratogenic effects in fish fry and in frog tadpoles hatched from eggs exposed to lethal concentrations.

Atrazine shows low toxicity in bird species (from dietary studies). No studies are available on wildlife mammals. In ewes, a dosage of 30 mg/kg was embrytoxic and fatal to pregnant as well as non-pregnant ewes.

Bromacil

Bromacil controls a wide range of annual and perennial grasses, broad-leaf weeds, and certainwoody species.

Trade Names: Hyvarx, Hyvarxl, Urox B

Special Problems: There are no acceptable acute oral studies LD50 for technical bromacil.

8-day LC50 $\geq$10,000 ppm for mallard and bobwhite quail.

(PBS): No toxicity studies are available for mammalian wildlife species. Bromacil is relatively nontoxic to birds. Chickens showed a reduced rate of weight gain after ten daily doses of 250 mg/kg. Application rates of 20lbs./acre are considered not hazardous to chickens (Palmer and Radcleff 1969). The eight-day LC50 for mallard and bobwhite is greater than 10,000 ppm (Sherman and Kaplan 1975).

One acceptable subacute bobwhite quail and mallard duck study was received for an 83.4% active ingredient formulated with an LC50 >10,000 ppm there is sufficient information to characterize the toxicity of this product to birds as practically non-toxic.

The LC50 >10,000 ppm for 83.4% active ingredient was used to estimate an LC50 for the technical bromacil of > 8,778 ppm. This is considered practically non-toxic to mallard ducks and bobwhite quail.

Data gaps: There are no acceptable acute oral studies available. The guideline requirements for an acute oral LD50 on technical bromacil is not satisfied.

2,4-D

2,4-D 2,4-D is a general broad-leaf herbicide.

Trade Names:
- DMA-4
- DMA-6
- Formula 40
- Acme Hi-DEP
- Dymec
- Weedrhap A-4D; LV-5D; LV-6D; LV-Granular
- Brushrhap LV-4D
- Weedrhap A-6D; LV-Granular D
- Weedar 64A
- Aqua-Kleen
- Chipco Turf Herbicide
- Clean Crop Amine/4
- 2,4-D Weed Killer
- Clean Crop Low Vol 4 Ester Weed Killer
- Esteron 99; 99C; 6E; 76BE
- LV-4

Special Problems: 2,4-D is one of the most widely used herbicides in the world. Ester formations are toxic to highly toxic to aquatic invertebrates. Herbicide-killed roots may create food base for *Armillaria* root rot and may persist in sediments or groundwater for ten or more months in cold temperatures. Excessive contact causes skin and eye irritation.

Studies: Studies show low toxicity to birds. Acute and chronic toxicity studies in mammals revealed adverse effects following large doses.

LD50'S are 300-1,000 mg/kg for mammals (except dogs).

LD50 is 100 mg/kg for dogs.

Subchronic studies are currently in progress to clarify the low but measurable toxicity of 2,4-D formulations.

(PBS): Toxicity to aquatic organisms depends on the specific formulation. Most ester formulations are toxic to highly toxic to aquatic invertebrates and fish, while salt and acid formulations are generally only slightly toxic to these organisms. Studies indicate that 2,4-D and its formulations have low toxicity to birds. Acute and chronic toxicity studies in mammals revealed adverse effects following large doses - LD50s 300-1,000 mg/kg (except for dogs 100 mg/kg).

Salts are most readily absorbed through plant roots, esters through foliage. Salts interfere with normal cell growth and impair respiration, food reserves, and cell division. 80mg/kg dose of dimeth salt of 2,4-D caused congestion of all organs, degenerative nerve cells, and human death. Excessive dermal contact causes skin irritation, tingling of extremities, nausea and vomiting, muscles aches and loss of function. It is an eye irritant, and prolonged breathing of spray causes coughing, burning, dizziness, and temporary loss of muscle coordination. 2,4-D is a suspected carcinogen. No bioaccumulation is known. Sub-chronic toxicity, Rowe and Hymas (1954), Mullison (1981), and Hill and Carlisle (1947, in US DOE,1983) showed no effect. A third rat study (DOE,1983) also showed "no effect". Subchronic studies are currently in progress to clarify the low but measurable toxicity of 2,4-D formulations.

2,4-DP

2,4-DP (Dichlorprop) 2,4-DP is a post-emergence herbicide which is more selective than 2,4-D.

Trade Names:	Weedone 2,4-DP
	Woody Plant Herbicide

Special Problems: 2,4-DP is similar to other phenoxy herbicides (2,4-D), is slightly toxic to fish, mildly toxic to mammals, and is lipid rather than water soluble.

Studies: Studies have been with chicken egg.

(PBS): In general, the toxic effects, environmental behavior, and fate of 2,4-DP are very similar to other phenoxy herbicides including 2,4-D. Very little information is available concerning specific 2,4-DP toxicity and environmental behavior. Therefore, this Herbicide Background Statement is brief and is supplemented by reference to 2,4-D. Post-emergence herbicide...more selective than 2,4-D. Toxicity data for

invertebrates is unavailable. Slightly toxic to fish and mildly toxic to mammals. No conclusive studies demonstrating either mutagenicity or carcinogenicity. Lipid rather than water soluble.

(PBS) (DP-9) (chicken egg studies) No other data are available; however, assuming bird response to 2,4-DP is similar to response to 2,4-D, 2,4-DP has a low toxicity to birds (mammals DP-12).

Dalapon

Dalapon Dalapon is used for grass control.

Trade Names: Dowpon
Dowpon Grass Killer (M)
Dalapon 85
Dowpon M

Special Problems: Dalapon is slightly toxic to most invertebrates and microorganisms, slightly toxic to fish and amphibians, and very mobile in soil. It is not metabolized in plants or persistent in seeds.

Studies: Studies have been done with Japanese quail, ring-necked pheasant, mallards, bobwhite quail, and chickens.

(PBS): Grass control: Except for some aquatic crustacea and insects, it is only slightly toxic to most invertebrates and microorganisms. It shows generally low toxicity to various microorganisms. Dalapon is slightly toxic to fish and amphibians. It shows low toxicity to birds, but reproductive effects are shown at high doses. Dalapon sodium salt was not reported to be carcinogenic in a two-year study of dogs and rats. No mutagenicity testing has been reported. Dalapon does not persist in soil and is very mobile by leaching. It is not metabolized in plants and in at least some species, extremely persistent, with dalapon carried via seeds through as many as three generations (wheat seedlings) (Foy,1975).

Dietary studies and egg injection bioassays with Dalapon indicate a low toxicity to birds. Japanese quail, ring-necked pheasant, and mallard ducks ingested up to 5,000 ppm dalapon in their diet for five days without mortality according to Hill et al.,(1975). In other studies reviewed by Kenaga, pheasants, bobwhite, and mallards all suffered some mortality at dalapon concentrations of 5,000 ppm in food during chronic feeding studies (110 to 169 days), and mallards had high levels of mortality with dalapon concentrations of 1,000 ppm in food.

In chickens, an acute oral LD50 is 5,660 mg/kg body weight for mixed sexes of chicks. After ten days of ingestion by capsule, no effects were seen in chickens at 100 mg/kg body weight, but at 250 and 500

mg/kg body weight, reduced weight gain was observed compared to controls. (Da-23): reproductive effects have been reported when dalapon was administered at high doses to birds.

Dicamba

Dicamba Dicamba is a general broad-leaf herbicide.

Trade Names: Banvel; 1OG; 4S; 5G; 4WS; XP Pellet; II; CST.

Special Problems: Dicamba is a mild skin irritant and a low grade eye irritant. In acid form it is insoluble in water. In salt form it is very soluble. Dicamba is one of the most mobile herbicides in soil.

Studies: Chronic exposure consumption (mice and rabbits) has been studied. Dicamba shows low toxicity to birds (pheasants and mallards). Acute and chronic exposure (mice, rats, rabbits, and guinea pigs) has been studied.

(PBS): For invertebrates and microorganisms LC50>100ppm. Dicamba is slightly toxic to fish and amphibians (LC50s > 10ppm). Mammals show dicamba as a mild skin irritant,a moderate skin sensitizer, and a transient low grade eye irritant. Chronic consumption by mice caused decreased body weights and increased liver weights. In rabbits post-implantation losses, decreased number of live fetuses, and decreased fetal weights occurred. Not considered to be mutagenic, the acid form of dicamba is relatively insoluble in water and highly soluble in most organic solvents. Salt formulations are all water soluble. Persistence of dicamba is markedly affected by rainfall, soil pH, and temperature. This is one of the most mobile herbicides measured in soil.

(PBS): Dietary studies and egg injection bioassays with dicamba indicate a low toxicity to birds. Acute oral toxicities of dicamba in birds ranged from an LD50 of 673 mg/kg in female pheasants (Edson and Sanderson 1965) in Pimental (1971) to an LC50 of 2,000 mg/kg in mallards. In eight-day subchronic feeding studies with birds, dicamba toxicities were reported as LC50's >10,000 ppm for all species and formulations studied with the exception of a reported LC50 >4,600 ppm for Banvel 310 in mallards (Velsicol Chemical Corp. data and U.S. EPA registration data cited in Ghassemi et al. (1981).

(PBS): Dunachie and Fletcher (1970) reported a decreased rate of hatching compared to controls in chicken eggs injected with dicamba at doses of 400 ppm in the egg. No effect was observed at 300 ppm, although an anomalous low hatch due to early mortality was observed at concentrations of 200 ppm dicamba in the eggs. No teratogenic effects (e.g., feather blanching) were observed in this study. The potential health hazards from acute and chronic exposure to dicamba

have been evaluated primarily in laboratory animal such as mice, rats, rabbits, and guinea pigs. (Dicamba-21) does not bioaccumulate in animals.

10 LC50 studies; 3 LD50 studies acceptable: (two technical, 11 of four formulations).

Technical dicamba acid dietary toxicity: available information on formulated dicamba products is sufficient to characterize dicamba acid and its salts as practically non-toxic to avian wildlife in dietary exposures. An additional acute oral study (with technical dicamba acid) is required to allow toxicity characterization of dicamba acid and its salts to avian wildlife.

Due to the absence of some appropriate environmental fate and non-target organism toxicity data, a full Ecological Effects Hazard Assessment cannot be completed at this time. Available acute toxicity data indicate that dicamba is practically non-toxic to fish and wildlife and unlikely to directly affect these organisms. Endangered species are not expected to be afffected by any dicamba use.

Data gap: An avian acute oral study with technical dicamba is required.

Diuron

Diuron Diuron is a substituted ures compound used as a pre- and post-emergent herbicide. It is used as a soil sterilant in non-crop areas and rights-of-way for total vegetational control.

Trade Names:	Karmex
	"B" inert list Diuron 4L
	Diuron 80 KRONAR
	Diuron 80WP

Special Problems: Diuron is persistent in soils; it usually won't leach >6". It is irritating to broken skin. There is evidence of bioaccumulation in carp and other aquatic invertebrates. Diuron is dissolved by lipids. In soil, diuron degrades (3,4-DCA) and can hydrolyze to form a possible carcinogen, TCAB.

Studies: Studies with dogs and rats show that diuron is slightly toxic to mammals. There is bioaccumulation in carp and other aquatic invertebrates. It is relatively toxic to chickens at low doses. In bluegill, emulsifiable diuron-TCA is more toxic than 80 percent wettable powder. Diuron is toxic to lower aquatic organisms.

In eight-day dietary studies LC50 for bobwhite quail is 1730 ppm,

>500 ppm for Japanese quail, ring-necked pheasant (chicks), and mallard (ducklings).

(PBS): (trade name: KROVAR) Diuron is a substituted urea compound used as a pre- and post emergent herbicide. Used as a soil sterilant in non-crop areas (road right-of-ways) for total vegetation control. It is relatively persistent in soils and under typical soil conditions will not leach more than six inches below the soil surface. Oral toxicity: approximate dose to kill a 150 lb. man is one cup full. Diuron is moderately irritating to broken skin in doses down to 10 percent water suspension formulation. Studies in 1974 indicate that although acute toxicity is low, chronic effects may be significant.

There is no evidence of diuron being carcinogenic to dogs or rats (1974), but it is suspected of affecting DNA (mutagenic), (1974). There is evidence of bioaccumulation in carp and aquatic invertebrates (diuron dissolved by lipids (organic solvents), such as body fat rather than water). It is considered as "slightly toxic" to mammals; no studies on mammalian wildlife are available. Diuron is "relatively toxic" to chickens at low doses. The Environmental Protection Agency (EPA) has requested further mutagenicity testing (1983). It is very persistent in soils, especially those with high clay and/or organic content. When applied at rates from 0.5 to 100 lbs./acre, the contact activity of the spray can be greatly increased with a surfactant. Degradation of diuron in soil, 3,4-dichloroaniline (3,4-DCA) can hydrolyze to form a possible carcinogen, TCAB.

The toxicity of diuron in aquatic environments is dependent on the herbicide formulation. In studies with bluegill, the emulsifiable diuron-TCA was much more toxic than the 80 percent wettable powder (Pimentel 1971). There is evidence of bioaccumulation in carp and aquatic invertebrates. It is considered quite toxic to lower aquatic organisms.

(PBS): Diuron is slightly toxic to mammals. No studies on mammalian wildlife are available. Diuron is toxic to chickens at relatively low doses. Diuron has a low order of acute toxicity to other birds that have been tested. The eight-day dietary LC50 for bobwhite quail is 1,730 ppm, and is greater than 5,000 ppm for Japanese quail, ring-necked pheasant (chicks), and mallard (ducklings). The LD50 for a single oral dose is greater than 2,000 mg/kg for the mallard.

In one acute oral toxicity study, technical diuron is practically nontoxic to birds on an acute basis. The avian acute guideline requirement has been satisfied by the evaluated document.

Three acceptable subacute dietary toxicity studies have shown that

technical diuron is slightly toxic to upland game birds and practically non-toxic to waterfowl on a dietary basis. The avian subacute dietary guideline requirements have been satisfied by the evaluated documents.

Fosamine

Fosamine Fosamine is used in selective woody plant control/post emergence.

Trade Names:	Krenite
	Krenite S

Special Problems: Krenite causes algae inhibition. It is a mild to moderate skin irritant and a respiratory irritant. Krenite is relatively toxic to a wide variety of nontarget plant species; even moderately and resistant plants will have some suppression of terminal growth.

Studies: In acute toxicity and dietary studies with mallards and bobwhite quail LC50S >100 ppm. To fish, sublethal effects in salmon at 8.9 ppm (avoidance).

(PBS): Major trade name:KRENITE. Krenite is used in selective woody plant control/post emergence to inhibit or prevent bud development. Algae showed inhibition of nitrogen fixation at 100ppm. Krenite is practically nontoxic to fish (LC50s > 100 ppm) Sublethal effects were seen in salmon at 8.9 ppm (avoidance). Without surfactant it is not considered an eye irritant; with surfactant, it is. Krenite is a mild to moderate skin irritant. No bioaccumulation is shown in animals; it shows short persistence in plants. There is very short persistence in soil, and it strongly adsorbs to soil particles; it is not mobile and is rapidly degraded. Very few reports of animal studies on fosamine toxicity are available in the open literature; most have been conducted by the manufacturer. It is relatively toxic to a wide range of nontarget plant species and even moderately-resistant-to-resistant plants will have some suppression of terminal growth.

(PBS): Acute toxicity and dietary studies with birds (mallard and bobwhite quail) conducted by E.I. DuPont de Nemours Co. are summarized. Both species have reported acute oral LD50's greater than 5,000 mg/kg body weight following incubation of up to 5,000 mg fosamine ammonium/kg with less than 50 percent mortality (actual value unreported) in ducks and no mortality in quail. In subacute oral studies, no mortalities were observed in ducks, and variable mortalities were observed in quail, when fed concentrations of up to 10,000 ppm in feed for 5 days. Other than some evidence of reduced body weight gain and decreased food consumption in some studies,

no abnormal effects attributable to fosamine ammonium were reported.

Fosamine ammonium is a relatively new herbicide that has not been extensively tested. Based on data from acute and subchronic toxicity studies, fosamine ammonium is mildly toxic. Formulations cause mild eye, skin, and respiratory irritation. Fosamine ammonium is not a skin sensitizer. No teratogenic, reproductive, or embryo-fetal toxic effects have been induced with fosamine ammonium. Carcinogenicity studies have not been reported for fosamine. Fosamine ammonium does not bioaccumulate in animals and, once absorbed, is rapidly metabolized to carbamoylphosphonic acid which, with parent fosamine ammonium, is rapidly eliminated in feces and urine.

Glyphosate

Glyphosate Glyphosate is a general plant herbicide.

Trade Names:	Roundup (first registered for use in 1974)
	Rodeo
	Accord

Special Problems: Glyphosate shows toxic surfactants in formulation. It is persistent in sandy loam soils and is usually adsorbed to soil components. Minute amounts can cause non-target plant damage.

Studies: Studies indicate low toxicity to avian species with no bioaccumulation. Acute oral toxicity was >2,000 mg/kg/day for bobwhite quail and >4,000 ppm for mallards and bobwhite (eight-day dietary toxicity).

(PBS): Roundup and Rodeo are two major formulations. Roundup is toxic to some species due to the presence of toxic surfactants. It is absorbed by plant foliage and readily translocated throughout the plant. Roundup shows low lipid solubility and has little tendency to bioaccumulate in animals. It is a non-leacher. Several studies have shown that glyphosate does not adversely affect soil microorganisms or their metabolic processes. No adverse effects to nitrogen fixation, nitrification, or denitrification activity have been seen. However, a 1983 study by Eberach et al. showed a persistence of Roundup in sandy loam which reduced nitrogen fixation, growth, and nodulation of subterranean clover planted 120 days after glyphosate treatment. It is strongly adsorbed to soil particles (see above note about sandy loam). Comes, et al. (1976) studied leaching of residues from irrigation canal banks and found that if glyphosate was applied to ditchbank vegetation in the fall after draining the canals, there was little to no chance of having residues contaminating irrigation water the following spring.

(PBS): (G-14): in general, glyphosate appears to have low toxicity to avian species. (G-15): very few published reports on the toxicity of glyphosate in mammals appear in the open literature since almost all of the data are proprietary. (G-21): it has little tendency to bioaccumulate in animals.

(PBS): Based on an acute oral toxicity of >2,000 mg/kg/day for bobwhite quail, glyphosate is no more than slightly toxic on an acute oral basis. Available data indicate that the 8-day dietary toxicity of glyphosate is >4,000 ppm for both mallard ducks and bobwhite quail. Based on the forgoing data, the Agency has determined that glyphosate is no more than slightly toxic to birds. Avian reproduction studies indicate reproductive impairment would not be expected at dietary levels up to 1,000 ppm.

Hexazinone

Hexazinone Hexazinone is a selective herbicide for site preparation and release of conifers. It is non-selective for weeds and woody plants.

Trade Names:	Velpar: L B/Velpar RP
	Velpar Gridballs
	Pronone 5G, -10G

Special Problems: Velpar leaches from the soil and is moderately persistent in water. It is more soluble in organic solvents.

Studies: When exposed to hexazinone, black-capped chickadees, ring-necked pheasants, and five other birds species did notseem to be attracted. Cottontail rabbits, prairie voles, white-tailed deer, Norway rats, grey squirrels, raccoons, skunks, and an oppossum were exposed to gridballs in their natural habitat. Studies show a slight toxicity to game birds and bobwhite quail.

(PBS): (Velpar) Velpar is a selective herbicide for site preparation and release of conifers. It is a non-selective herbicide for weeds and woody plants.

Velpar is toxic to algae. It is practically non-toxic to aquatic invertebrates (LC50>10ppm) and fish (LC50>100 ppm). It is relatively non-toxic to birds and mildly toxic to mammals exposed by oral, dermal, and inhalation methods. Velpar is not carcinogenic in rats and mice and proved nonmutagenic in four out of five test systems examined. It leaches from soil, tending to go downwards rather than horizontally with the amount of leaching dependent upon field conditions. Velpar is moderately persistent in water and more soluble in most organic solvents than it is in water.

Birds do not seem to be attracted to hexazinone, as evidenced by a study in which Velpar gridballs were placed near the food of captive black-capped chickadees and ring-necked pheasants, as well as near feeding sites frequented by these two species and five other bird species. During an observation period of up to three weeks, birds made no response to the gridballs. (H-16): a few observations of common wildlife mammals have been reported. (H-19): the results of placing Velpar gridball pellets in the feeding area of common wildlife mammals are summarized in Table 2-1. Cottontail rabbits, prairie voles, white-tailed deer, Norway rats, and grey squirrels were exposed to gridball pellets in their natural habitat. Raccoons, skunks, and an oppossum were live-trapped and exposed to Gridball pellets. Among all of these animals, even when deprived of regular diet, only one prairie vole nibbled the Gridball pellets. No mortality, unusual behavior, or apparent illness was observed in these wildlife mammals. (pH-25) [H] does not bioaccumulate appreciably in animals, and tissue residues of both hexazinone and its metabolites decreases rapidly when exposure ot hexazinone ceases.

Data indicate that technical hexazinone is slightly toxic to upland game birds. Technical hexazinone produced an oral LD50 value of 2,258 mg/kg with 95% confidence limits of 1,628 to 3,130 mg/kg. A laboratory test consisted of five control groups in five dosage levels, 398-2,510 mg/kg. The birds were 20 weeks old and weighed approximately 207 g.

Technical hexazinone is practically non-toxic to mallard ducks. The LC50 is estimated to be greater than 10,000 ppm. The dietary LC50 for technical hexazinone was greater than 10,000 ppm. The acute dietary LC50 of the positive control (Dieldrin) was calculated to be 163.4 ppm.

The LC50 value >5,000 ppm suggests that technical hexazinone is practically non-toxic to bobwhite quail.

Picloram

Picloram Picloram is used in range management and noxious weed control.

Trade Names: Tordon 2K, -10K, -22K, -K, Amdon

Special Problems: Picloram is moderately to highly persistent in soil, with a half life greater than four years in arid regions. It can be relatively mobile, and K-salt and acid formulations are easily leached. There is broad phytotoxicity (toxicity to plants) in small amounts.

Studies: Benign liver tumors were induced in female rats which were

exposed to picloram. It does not bioaccumulate in animals. It is slightly toxic to most species of fish; lake trout fry survival is reduced at 35 ppb.

(PBS): Tordon and Andonare are used in range management and noxious weed control. Picloram is relatively non-toxic to soil microorganisms at concentrations up to 1,000 ppm. Picloram is particularly prone to accumulate in new plant growth. Picloram is moderately to highly persistent in soil. It has a half life of approximately one month under highly favorable conditions, to a half life of more than four years in arid regions. It can be relatively mobile, and potassium salt and acid formulations are easily leached. Salt formulations are water soluble and have the potential for high concentrations in runoff from heavy rainfall occurring soon after application.

For most species of fish, picloram formulations are only "slightly toxic" with median LC>10 ppm. It appears to present little or no carcinogenic risk, although bioassays on mice and rats suggested the ability to induce benign liver tumors in rats. A NCI (National Cancer Institute) 1978 study of O-M rats suggests the ability of picloram to induce benign tumors in the livers of female O-M rats. Reuber (1971) interpreted test results of picloram studies as being carcinogenic.

The toxic effects of picloram in birds have been investigated in a small number of studies. No studies have been conducted on wildlife to date. Picloram does not bioaccumulate appreciably in animals and is rapidly excreted, virtually unchanged, primarily in the urine.

There are twelve studies acceptable for use in a hazard assessment, and three studies fulfill the requirements for avian acute dietary studies. According to these findings, picloram appears to be practically nontoxic to birds. However, a single dose oral LD50 test is still required.

Five studies have been submitted on picloram mixtures. All were acceptable for fulfilling possible guideline requirements on a mixture (practically non-toxic).

Simazine

Simazine is used in the selective control of annual and perennial grasses and broad-leaved weeds, algae, and aquatic plants.

Trade Names: Simazine 80
80W Fogard S (25% Atrazine 37.5% Simazine)
Princep 80W
4G Simazine AL, "B" inert list
Aquazine

Special Problems: Simazine is toxic at concentrations >10 ppm to invertebrates and microorganisms. It is moderately persistent in soils and resistant to leaching. Simazine used with Tween 80 wetting agent is a problem combination.

Studies: Sublethal effects have been seen in trout (when simazine is used with Tween 80). Fogard S has induced malignant tumors in mice. It is nonlethal to crustacea (snails, oysters, and worms). Waterfowl reproduction is not affected at 20 ppm. Acute toxicity is seen at >2,000 mg/kg in microtine rodents (voles) and >5,000 mg/kg in other species.

(PBS): Simazine is used in the selective cotrol of annual and perennial grasses and broad-leaved weeds, algae, and aquatic plants. It does not readily penetrate plant foliage, although the addition of an adjuvant, such as mineral oil, tends to increase the foliar penetration.

This herbicide is toxic at concentrations >10 ppm to invertebrates and microorganisms. It is moderately persistent in soil (resistant to leaching and readily adsorbs to soil particles). In water it is moderately persistent with a half life of 50-70 days. Simazine is only "slightly toxic" to fish. Sublethal effects (Dodson and Mayfield 1979) of technical grade simazine and Tween 80, a wetting agent, decreased the swimming speed of trout and their response to currents. This effect was believed to be from the Tween 80 wetting agent. Limited study with Fogard S (37.5% simazine and 25% atrazine) by Donna et al. (1981), indicated a potential to induce malignant tumors in mice. Innes et al. (1969), study indicated simazine lacks carcinogenic potential. It is weakly mutagenic.

(S-17): Some nonlethal effects of simazine were observed in crustacea at relatively low doses. In invertebrates other than arthropods (i.e. in snails, oysters, and worms), the few studies with simazine generally indicate toxic effects at relatively low concentrations, particularly in field studies. Mortality observed in the field populations may have been due to a synergistic effect between herbicide effects and death of algae in the lake.

(SC-14c): The minimum data requirements have been fulfilled. Testing formulated products on avian species may be required. Chronic testing with avian species may also be required. Simazine persists in soil and water, is readily taken up by plants, and according to predicted residues, will persist on treated vegetation such as seed pods. An avian reproduction study would be required for all the uses for which simazine is registered. The study submitted partially fulfills this requirement. An avian reproduction study on an upland game bird species is still required.

The avian studies show that simazine is practically non-toxic to birds and will not affect reproduction of waterfowl at 20 ppm (the highest level tested).

(PBS): Studies in wild animals have been restricted to microtine rodents (voles). Simazine generally has low toxicity for these species; the acute toxicity following ingestion is greater than 2,000 mg/kg in voles and greater than 5,000 mg/kg in the other species. (pS-27) Simazine has a low tendency to bioaccumulate in animals and, once absorbed by animals, it is rapidly metabolized to nontoxic metabolites that are readily excreted via the kidneys.

Triclopyr

Triclopyr is a selective herbicide for woody plants and broad-leaved weeds which was originally developed for utility rights-of-way and on industrial sites.

Trade Names: Garlon 3A
Turflon Amine
B/Garlon 4 (Turflon ester)

Special Problems: Triclopyr appears to bioaccumulate in plants and is persistent in soils where cool soil temperatures are not favorable to microbial conditions. It is capable of leaching and running off in water. Formulations are combustible, and extended exposure corrodes aluminum. Garlon 3A is severely injurious to the eyes.

Studies: Studies with mammals show low to moderately acute toxicity, mild subchronic toxicity, and no chronic toxicity. No carcinogenic cellular activity was seen in rodents. It is mildly fetotoxic, but not teratogenic. Low acute oral toxicity to mallards was seen. Subchronic feedings (mallards and bobwhite quail) were conducted.

(PBS): Garlon is a selective herbicide used for control of a variety of woody plants and broad-leaved weeds. It was originally developed for control of vegetation along utility rights-of-way and on industrial sites. It is particularly effective in control of root-sprouting plant species. Application should occur soon after full leaf development where there is sufficient soil moisture for plant growth. Garlon appears to bioaccumulate in plants (Finland and Texas studies). There is short persistence in soil because it is not strongly adsorbed to soil particles (relative to the amount of organic material found in the soil). Persistence strongly depends on specific soil type and climatic conditions. The average half life in soil is 46 days. In Sweden (Torstensson and Stark 1982), triclopyr residues persisted one to two years (and sometimes more than two years), because cool soil temperatures were not favorable to microbial conditions.

Garlon 3A: Garlon 3A is a triethylamine salt formulation; Garlon 4 is a butoxyethyl ester formulation. Formulation with picloram is available (M-4450). Triclopyr is more soluble in organic solvents than it is in water. The triclopyr acid formed by photodegradation and microbial decomposition is neutralized to a salt under normal environmental pH's. Triclopyr formulations are combustible. On extended exposure, there is some corrosion to aluminum. Garlon 4 is not an eye irritant in rabbit tests. Garlon 3A is severely injurious to the eyes and is labeled as such.

Triclopyr is a relatively new herbicide for which very limited toxicity data have been reported. Studies with mammals indicate low to moderately acute toxicity, mild subchronic toxicity, and no chronic toxicity. In limited studies with rodents, no carcinogenic activity has been noted. It is mildly fetotoxic, but not teratogenic.

The majority of the data are from the manufacturer. (T-14): the toxic effects of triclopyr have been investigated in birds in a small number of studies conducted by the Dow Chemical Company. Triclopyr and its formulations have a low acute oral toxicity to mallard ducks, with LD50's of 1,698, 3,176, and 4,640 mg/kg body weight for triclopyr, Garlon 3A, and Garlon 4, respectively. Eight-day subchronic feeding studies have been conducted for mallard ducks and both bobwhite and Japanese quail with triclopyr, and for mallard ducks and bobwhite quail with Garlon 3A and Garlon 4. Subchronic oral toxicity of triclopyr and its formulations is low in these species, with LC50's from 2,935 to greater than 5,000 ppm for unformulated triclopyr, LC50's greater than 10,000 ppm for Garlon 3A, and LC50's greater than 9,000 ppm for Garlon 4. No field studies on the toxic effects of triclopyr or its formulations in birds have been reported. (pT-21) The available information on the metabolism and bioaccumulation of triclopyr in animals is derived from data originated by the Dow Chemical Company. Results indicate that triclopyr is rapidly cleared from animal systems, primarily via the kidneys.

Tebuthiuron

Tebuthiuron Graslan is used for brush and weed control in rangelands. Spike is used for control of grasses, broad-leaf weeds, and woody plants.

Trade Names:	Spike 80W, -5G, -1G, -20P, -40P
	Spike Brush Bullets
	Spike Dry Flow
	Spike/Treflan 6G
	Graslan 80W, 20P

Special Problems: Threatened and endangered plant species could be unreasonably threatened.

Studies: Studies have been accute oral and subchronic oral on chickens, quail, and ducks.

Tebuthiuron is EPA listed as a relatively low order of toxicity.

(PBS): Studies on the toxic effects of tebuthiuron in birds include single-dose and multiple-dose acute oral studies, a subchronic oral study, and two chronic oral studies. These studies, conducted on chickens, quail, and ducks, indicate a low order of toxicity of tebuthiuron to birds. (Te-19): tebuthiuron is considered by the U.S. EPA to have a relatively low order of toxicity. (Te-28): data indicate that tebuthiuron and its metabolites do not bioaccumulate in birds and mammals following oral exposure.

Inerts Listing For Herbicide Formulations

(FEBRUARY, 1988)

Inert ingredients in pesticide formulations are an increasingly important issue, especially when some testing has shown that they may have detrimental effects to the environment, human health, and wildlife species. An inert ingredient is defined as any intentionally added ingredient in a pesticide product which is not pesticidally active. They may be solvents, surfactants, emulsifiers, flow conditioners, and other functional ingredients of the herbicide formulation. Cumulative effects of the known ingredients and the full formulations on lethal, sublethal, acute, chronic, and indirect effects to wildlife are relatively unknown. The inert ingredients may exert independent effects or interact synergistically with the known ingredients.

Generally, the identity of these inert ingredients is proprietary information of the herbicide manufacturer. The Environmental Protection Agency's (EPA) toxicological tests for registration purposes have regularly concentrated only on the active ingredient of the formulation, rather than the formulation as a whole. The listing of inert ingredients in categories is an effort to help provide data where unknown chemical combinations have not been tested for their effects on human health and the environment.

In developing their policy on inert ingredients, the EPA has divided approximately 1,200 intentionally added inert ingredients into four toxicity categories or lists:

List 1 Inerts of Toxicological Concern

This list contains about 50 inert ingredients EPA has identified as being of significant toxicological concern.

List 2 Potentially Toxic Inerts/High Priority For Testing

This list contains about 60 inert ingredients that are structurally similiar to chemicals known to be toxic; some have data suggesting a basis for concern about the toxicity of the chemical.

List 3 Inerts of Unknown Toxicity

This list contains approximately 800 inert ingredients that EPA has no basis for inclusion on other lists.

List 4 Inerts of Minimal Concern

This list contains approximately 300 inert ingredients that EPA regards as innocuous. Examples are substances generally recognized as safe by the Food and Drug Administration.

The Forest Service has adopted the policy to only use pesticides that do not contain inert ingredients indicated on EPA's Lists 1 or 2 unless the risk associated with the inert ingredient is evaluated and found acceptable. A framework of three lists for the use of pesticides and inert ingredients has been developed by the Forest Service:

List A Pesticide Products by Active Ingredient that DO NOT CONTAIN Inert Ingredients on EPA Lists 1 or 2.

List B Pesticide Products by Active Ingredient that CONTAIN Identified Inert Ingredients on EPA Lists 1 or 2.

List C Pesticide Products That CONTAIN Unidentified Inert Ingredients on EPA Lists 1 or 2.

In line with the above policy, the Forest Service has recommended to its resource managers to use products containing inert ingredients on List A if labeled for their needs. If no product on List A is labeled for their needs, then use a product from List B with the understanding that they will evaluate the risk of the inert ingredient. Use of products with inert ingredients on List C will be limited to stock on hand. As additional information becomes available, the lists will be updated

"A" LIST (DO NOT CONTAIN INERT INGREDIENTS ON EPA LISTS 1 OR 2)

ACTIVE INGREDIENT	CHEMICAL CO	PRODUCT NAME	EPA REGISTRATION NUMBER
AMITROLE	RHONE-POULENC AG. (UNION CARBIDE)	AMITROLE T LIQUID	264-135
	RHONE-POULENC AG. (UNION CARBIDE)	AMITROLE T LIQUID (LAWN & GARDEN)	264-226
	RHONE-POULENC AG. (UNION CARBIDE)	AMIZOL INDUSTRIAL	264-119
	RHONE-POULENC AG. (UNION CARBIDE)	WEEDAZOL HERBICIDE	264-68
ASULAM	RHONE-POULENC AG. (UNION CARBIDE)	ASULOX	359-662
ATRAZINE	DUPONT	ATRAZINE 80W	352-410
	CIBA-GEIGY	AATREX 80W	100-439
(SEE B LIST)	DREXEL	ATRAZINE 80	19713-6
	DREXEL	ATRAZINE 90	19713-76
	ACETO	ATRAZINE 80W	2749-150
BROMACIL	DUPONT	HYVAR X	352-287
	DUPONT	HYVAR XL	352-346
	HOPKINS AG. CHEM.	UROX B	2393-298
2,4-D	DOW	DMA4	464-196
	DOW	DMA6	464-151
	DOW	FORMULA 40	464-001
	PBI/GORDON	ACME HI-DEP	2217-703
	PBI/GORDON	DYMEC	2217-633
	INTERAG (VERTAC)	WEED RHAP A-4D	39511-64
	INTERAG (VERTAC)	WEED RHAP LV-5D	39511-74
	INTERAG (VERTAC)	WEED RHAP LV-4D	39511-75
	INTERAG (VERTAC)	WEED RHAP LV-6D	39511-81
	INTERAG (VERTAC)	WEED RHAP LV-	39511-77
	INTERAG (VERTAC)	BRUSH RHAP LV-4D	39511-58
	INTERAG (VERTAC)	WEED RHAP A-6D	39511-67
	INTERAG (VERTAC)	WEED RHAP LV- GRANULAR D	57539-19
	INTERAG (VERTAC)	FORMULA 40	464-1-39511

ACTIVE INGREDIENT	CHEMICAL CO	PRODUCT NAME	EPA REGISTRATION NUMBER
(continued)	INTERAG (VERTAC)	DMA 4	464-196-39511
	RHONE-POULENC AG (UNION CARB)	WEEDAR 64A	264-143
	RHONE-POULENC AG (UNION CARB)	AQUA-KLEEN	264-109
	RHONE-POULENC AG (UNION CARB)	WEEDAR 64	264-2
	RHONE-POULENC AG (UNION CARB)	CHIPCO TURF HERBICIDE D	359-491
	PLATTE CHEMICAL	CLEAN CROP AMINE/4	34704-5
	PLATTE CHEMICAL	2,4-D WEED KILLER	34704-120
	PLATTE CHEMICAL	CLEAN CROP LOW VOL 4 ESTER WEED KILLER	34704-124
(ALSO SEE B LISTS)			
2,4-DP (SEE B LIST)			
DALAPON	DOW	DOWPON	464-164
	DOW	DOWPON GRASS KILLER(M)	464-402
	FERMENTA	DALAPON 85	50534-55
	INTERAG (VERTAC)	DOWPON M	464-402-39511
DICAMBA	SAND0Z	BANVEL HERBICIDE	55947-1
	SANDOZ	BANVEL 10G	55947-2
	SANDOZ	BANVEL 4S	55947-4
	SANDOZ	BANVEL 5G	55947-14
	SANDOZ	BANVEL 4WS	55947-18
	SANDOZ	BANVEL XP PELLET	55947-21
	SANDOZ	BANVEL II	55947-28
	SANDOZ	BANVEL CST	55947-32
	SANDOZ (VELSICOL)	BANVEL	876-25
	SANDOZ (VELSICOL)	BANVEL 10G	876-29
	SANDOZ (VELSICOL)	BANVEL 4S	876-37
	SANDOZ (VELSICOL)	BANVEL 5G	876-103
	SANDOZ (VELSICOL)	BANVEL 4WS	876-159
	SANDOZ (VELSICOL)	BANVEL XP PELLET	876-178
	SANDOZ (VELSICOL)	BANVEL II	876-255
	SANDOZ (VELSICOL)	BANVEL CST	876-441
DIURON	DUPONT	KARMEX	352-247
	DREXEL	DIURON 80	19713-21
(SEE B LIST)	ACETO	DIURON 80WP	2749-59
FOSAMINE AMMONIUM	DUPONT	KRENITE	352-376
	DUPONT	KRENITE S	352-395
GLYPHOSATE	MONSANTO	ACCORD	524-326

ACTIVE INGREDIENT	CHEMICAL CO	PRODUCT NAME	EPA REGISTRATION NUMBER
	MONSANTO	RODEO	524-343
	MONSANTO	ROUNDUP	524-308
HEXAZINONE	DUPONT	VELPAR	352-378
	DUPONT	VELPAR GRIDBALLS	352-387
	DUPONT	VELPAR L	352-392
	DUPONT	VELPAR GRIDBALLS	352-397
	PROSERVE	PRONONE 5G	33560-40
	PROSERVE	PRONONE 10G	33560-21
PICLORAM	DOW	TORDON 2K	464-333
	DOW	TORDON 10K	464-320
	DOW	TORDON 22K	464-323
	DOW	TORDON K	464-421
SIMAZINE	DREXEL	SIMAZINE 80	19713-46
	CIBA-GEIGY	PRINCEP 80W	100-437
SEE B LIST	CIBA-GEIGY	PRINCEP 4G	100-435
	CIBA-GEIGY	AQUAZINE	100-570
	ACETO	SIMAZINE 80W	2749-163
TRICLOPYR	DOW	GARLON 3A TURFLON AMINE	464-546
TEBUTHUIRON	ELANCO	SPIKE 80W	1471-97
	ELANCO	SPIKE 5G	1471-103
	ELANCO	SPIKE 1G	1471-104
	ELANCO	GRASLAN 80W	1471-109
	ELANCO	GRASLAN 20P	1471-119
	ELANCO	SPIKE 20P	1471-123
	ELANCO	SPIKE 40P	1471-124
	ELANCO	SPIKE BRUSH BULLETS	1471-129
	ELANCO	SPIKE DRY FLOW	1471-147
	ELANCO	SPIKE/TREFLAN 6G	1471-139

COMBINATIONS OF HERBICIDE FORMULATIONS — "A" LIST
(THESE DO NOT CONTAIN INERT INGREDIENTS ON EPA LISTS 1 OR 2)

AMITROLE & SIMAZINE	RHONE-POULENC AG (UNION CARBIDE)	AMIZINE HERBICIDE	261-124
	RHONE-POULENC AG (UNION CARBIDE)	LIQUID AMIZINE	264-196
BROMACIL & DIURON	DUPONT	KROVAR II	352-351
	DUPONT	KROVAR I	352-352

ACTIVE INGREDIENT	*CHEMICAL CO*	*PRODUCT NAME*	*EPA REGISTRATION NUMBER*
DICAMBA + 2,4-D	PBI/GORDON	BRUSH KILLER 4-41	2217-644
	PBI/GORDON	BRUSH KILLER 10-5-1	2217-543
	SANDOZ	BANVEL + 2,4-D	55947-5
	SANDOZ	WEEDMASTER	55947-24
	SANDOZ (VELSICOL)	BANVEL + 2,4-D	876-42
	SANDOZ (VELSICOL)	WEEDMASTER	876-203
PICLORAM + 2,4-D	DOW	TORDON 101	464-306
	DOW	TORDON 101R	464-510
	DOW	TORDON RTU	464-510

"B" LIST (CONTAIN INERT INGREDIENTS ON EPA LISTS 1 OR 2) INERT CONCERN LISTED

ACTIVE INGREDIENT	CHEMICAL CO	PRODUCT NAME	EPA REGISTRATION NUMBER
ATRAZINE	DREXEL	ATRAZINE 4L	19713-11
	DREXEL	ATRAZINE 5L	19713-80
	DREXEL	ATRAZINE 4L	352-409
CONCERN ** FORMALDEHYDE			
2,4-D	DOW	ESTERON 99	464-159
	DOW	ESTERON 99C	464-566
	DOW	ESTERON 6E	464-347
	DOW	ESTERON 76BE	464-279
	INTERAG (VERTAC)	ESTERON 76BE	464-279-39511
	INTERAG (VERTAC)	ESTERON 6E	464-347-39511
	INTERAG (VERTAC)	ESTERON 99C	464-566-39511
	DOW	LV 4	464-187
CONCERN ** PETROLEUM HYDROCARBONS (KEROSENE)			
2,4-D	DOW	ESTERON 44	464-463
CONCERN ** XYLENE AND KEROSENE			

ACTIVE INGREDIENT	CHEMICAL CO	PRODUCT NAME	EPA REGISTRATION NUMBER
2,4-DP	RHONE-POULENC AG (UNION CARBIDE)	WEEDONE 2,4-DP WOODY PLANT HERBICIDE	264-231
CONCERN ** OTHER PETROLEUM HYDROCARBONS (HEAVY AROMATIC NAPTHA)			
DIURON	DREXEL	DIURON 4L	19713-36
CONCERN ** FORMALDEHYDE			
SIMAZINE	DREXEL	SIMAZINE 4L	19713-60
CONCERN ** FORMALDEHYDE			

COMBINATIONS OF HERBICIDE FORMULATIONS — "B" LIST
INERT CONCERN LISTED

2,4-D + 2,4-DP	RHONE-POULENC AG (UNION CARBIDE)	WEEDONE 170 WOODY PLANT HERBICIDE	264-222
	RHONE-POULENC AG (UNION CARBIDE)	WEEDONE CB READY TO USE WOODY PLANT HERBICIDE	264-393
	RHONE-POULENC AG (UNION CARBIDE)	ENVERT 171 WOODY PLANT HERBICIDE	264-223
2,4-D + 2,4-DP + DICAMBA	PBI/GORDON	BRUSH KILLER 800	2217-651
	PBI/GORDON	ACME SUPER BRUSH KILLER	2217-651
CONCERN ** OTHER PETROLEUM HYDROCARBONS (HEAVY AROMATIC NAPTHA)			
TRICLOPYR + 2,4-D	DOW	CROSSBOW (TURFLON D)	464-589
TRICLOPYR + PICLORAM	DOW	TORDON 1 + 2 (ACCESS)	464-576
CONCERN ** PETROLEUM HYDROCARBONS (KEROSENE)			

Wildlife Literature Review for Herbicide Concerns

We recognize that specific research oriented to wildlife species generally has not been done. A review of the available literature that might be applicable was accomplished by enlisting the aid of INFO-NW at the University of Washington to search their data bases for information. In order to have the literature pertain as much as possible to the Pacific Northwest Region's wildlife species and the sixteen herbicides being addressed, a list of descriptors was used to help set the parameters of the search. This list will differ somewhat from the 129 wildlife species that have been shown to use the grass/forb stage of various plant communities (Appendix J-a). Reasons for the differences are related to the timing of the request to access the data bases, the lack of research on specific wildlife species in this Region, and the need to use the most current research that is available.

The life form numbers are from Management of Wildlife and Fish Habitats in Forests of Western Oregon and Washington (Brown, E.R. 1985).

Wildlife Descriptors- Literature Search

Amphibians	Life Form
1. NORTHWESTERN SALAMANDER - *AMBYSTOMA GRACILE*	2
2. WESTERN TOAD - *BUFO BOREAS*	2
3. BULLFROG - *RANA CATESBEIANA*	1

Wildlife Descriptors- Literature Search (continued)

Reptiles	Life Form
1. WESTERN POND TURTLE - *CLEMMYS MARMORATA*	3
2. COMMON GARTER SNAKE - *THAMNOPHIS SIRTALIS*	3

Birds	Life Form
1. COMMON LOON - *GAVIA IMMER*	3
2. WESTERN GREBE - *AECHMOPHORUS OCCIDENTALIS*	3
3. GREAT BLUE HERON - *ARDEA HERODIAS*	12
4. MALLARD - *ANAS PLATYRHYNCHOS*	3
5. TURKEY VULTURE - *CATHARTES AURA*	4
6. NORTHERN GOSHAWK - *ACCIPITER GENTILIS*	11
7. RED-TAILED HAWK - *BUTEO JAMAICENSIS*	12
8. RUFFED GROUSE - *BONASA UMBELLUS*	5
9. BLUE GROUSE - *DENDRAGAPUS OBSCURUS*	5
10. CALIFORNIA GULL - *LARUS CALIFORNICUS*	3
11. GREAT HORNEL OWL - *BUBO VIRGINIANUS*	12
12. RUFOUS HUMMINGBIRD - *SELASPHORUS RUFUS*	11
13. NORTHERN FLICKER - *COLAPTES AURATUS*	13
14. AMERICAN CROW - *CORVUS BRACHYRHYNCHOS*	11
15. BLACK-CAPPED CHICKADEE - *PARUS ATRICAPILLUS*	14
16. EUROPEAN STARLING - *STURNUS VULGARIS*	14
17. RED-WINGED BLACKBIRD - *AGELAIUS PHOENICEUS*	7

Mammals	Life Form
1. LITTLE BROWN MYOTIS - *MYOTIS LUCIFUGUS*	14
2. COYOTE - *CANIS LATRANS*	15
3. YELLOW-PINE CHIPMUNK - *TARNIAS AMOENUS*	15
4. NORTHERN POCKET GOPHER - *THOMOMYS TALPOIDES*	15
5. ELK - *CERVUS ELAPHUS*	5
6. MULE & BLACK-TAILED DEER - *ODOCOILEUS HEMIONUS*	5
7. COLUMBIAN WHITE-TAILED DEER - *ODOCOILEUS VIRGINIANUS LEUCURUS*	5
8. WESTERN RED-BACKED VOLE - *CLETHRIONOMYS CALIFORNICUS*	15
9. PORCUPINE - *ERETHIZON DORSATUM*	6
10. BRUSH RABBIT - *SYLVILAGUS BACHMANI*	5
11. EASTERN COTTONTAIL - *SYLVILAGUS FLORIDANUS*	15

OTHER
AQUATIC
MICROORGANISMS - ANY (PLANKTON, INVERTEBRATES)
NATIVE OYSTER
CLAMS
DUNGENESS CRAB
INSECTS - ANY
SOIL MICROORGANISMS - ANY

Akerman, J.W.,1979. Environmental Protection Agency's Regulatory Requirements for Wildlife Toxicity Testing. Avian and Mammalian Toxicology, ASTM STP 693, E.E. Kenaga, ed. American Society for Testing and Materials: pp. 3-8.

Anderson, A.E., 1960. Effects of Sagebrush Eradication by Chemical Means on Deer and Related Wildlife. Colorado Game and Fish Department. Project W-38-R-13. 72 pgs.

Anderson, A.E., et al.,1966. An Investigation of 2,4-D Application to Sagebrush Within a Mountain Shrub-Conifer Complex, Uncompahgre Plateau. State of Colorado, Job Completion Report W-114-R-1: pp. 391-420.

Basham, J.T.,1982. Effects of Herbicide Treatment on the Internal Pathological Quality of Surviving Aspen Suckers. Canadian Forestry Report No. 0-X-334; Sault Ste. Marie, Ontario, Canada.

Best, L.B.,1973. First Year Effects of Sagebrush Control on Two Sparrows. The Journal of Wildlife Management. 36(3): pp. 534-544.

Birge, W.J., et al. 1980. Effects of Organic Compounds on Amphibian Reproduction. US Department of Commerce, National Technical Information Service: PB80-147523. 39 pgs.

Bohmont, B.L.,1967. Toxicity of Herbicides to Livestock, Fish, Honey Bees and Wildlife. In: Proceedings of the 1967 Western Weed Control Conference. Vol. 21: pp. 25-27.

Broadbent, F.E.,1967. Nature of Soil Organic Matter. In: Proceedings of the 1967 Western Weed Control Conference. Vol 21: pp. 31-35.

Bush, P.B., et al. 1987. Suitability of Hardwoods Treated with Phenoxy and Pyridine Herbicides for Use as Firewood. Archives of Environmental Contamination and Toxicology. Vol.16: pp. 333-341.

Byrd, B.C.,1982. Pine Growth Twelve Years Following Site Preparation with Picloram Plus 2,4-D. In: Proceedings of the Southern Weed Science Society. January: pp. 200-209.

Call, D.J., et al. 1983. Toxicity, Bioconcentration, and Metabolism of Five Herbicides in Freshwater Fish. US Department of Commerce, National Technical Information Service. PB83-263681. 99 pgs.

Cambell, Dan L., et al. 1981. Acceptance by Black-tailed Deer of Foliage Treated with Herbicides. Res. Pap. PNW-290. U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station.

Cambell, T.E.,1982. Herbicide Spray Effects on Mixed Pine-Hardwoods. In: Proceedings of the Southern Weed Science Society. January: pp. 175-180.

Caldwell, R.S.,1977. Biological Effects of Pesticides on the Dungeness Crab (*Cancer magister*). U.S. Department of Commerce, Ecological Research Series: PB 276-978: 125 pgs.

Caldwell, Richard S., et al. 1979. Toxicity of the Herbicides 2,4-D, DEF, Propanil and Trifluralin to the Dungeness crab, *Cancer magister*. Tech. Pap. No. 4819. Oregon Agricultural Experiment Station.

Cholakis, J.M., et al. 1981. Acute and Subacute Toxicity of Pesticides in Microtine Rodents. Avian and Mammalian Wildlife Toxicology; Second Conference, ASTM STP 757; Lamb, D.W.; Kenaga, E.E., eds., American Society for Testing and Materials.

Crouch, G.L.,1979. Atrazine Improves Survival and Growth of Ponderosa Pine Threatened by Vegetative Competition and Pocket Gophers. Forest Science. 25 (1): pp. 99-111.

DeNoyelles, F.; Kettle, D..1980. Herbicides in Kansas Waters - Evaluations of the Effects of Agricultural Runoff and Aquatic Weed Control on Aquatic Food Chains. Kansas Water Resources Research Institute, Manhattan, Kansas. 52 pgs.

Dewey, S.L.,1986. Effects of the Herbicide Atrazine on Aquatic Insect Community Structure and Emergence. Museum of Natural History, Kansas University, Lawrence, Kansas.

Eijsackers, H.,1985. Effects of Glyphosate on the Soil Fauna. In: The Herbicide Glyphosate. Grossbard, E.; Atkinson, D., eds; London, England.

Ellgehausen, H., et al. 1980. Factors Determining the Bioaccumulation Potential of Pesticides in the Individual Compartments of Aquatic Food Chains. Ecotoxicology and Evironmental Safety 4(2): pp. 134-159.

Expert Panel Report on the Carcinogenicity of 2,4-D, 1987. Canadian Centre for Toxicology; Guelph, Ontario, Canada.

Fink, R.J.: Jaber, M.J.,1981. The Laughing Gull (*Larus atricilla*) as a Model for Assessment of Secondary Poisoning. Avian and Mammalian Wildlife Toxicology; Second Conference; Louisville, Kentucky: pp.66-71.

Folmar, L.C., et al. 1979. Toxicity of the Herbicide Glyphosate and Several of its Formulations to Fish and Aquatic Invertebrates. Archives of Environmental Contamination and Toxicology. 8(3): pp. 269-278.

Francis, B.M.; Lampman, R.L.,1985. Model Ecosystem Studies of the Environmental Fate of Five Herbicides Used in Conservation Tillage. Archives of Environmental Contamination and Toxicology. 14(6): pp. 693-705.

Fratello, B., et al. 1985. Effects of Atrazine on Soil Microarthropods in Experimental Maize Fields. Istituto di Anatomia; Universita di Modena; Modena, Italy.

Gadgil, R.L., et al. 1986. Relative Growth and Persistence of Planted Legumes in a Mid-rotation Radiata Pine Plantation. Forest Ecology and Management. 14(2): pp. 113-124.

Gashwiler, J.S.,1977. Bird Populations in Four Vegetational Types in Central Oregon. U.S. Department of the Interior, Fish and Wildlife Service. Special Scientific Report. Wildlife No. 205. Washington, DC.

Gorzinski, S.J., et al. 1987. Dietary Toxicity of Picloram Herbicide in Rats. Journal of Toxicology and Environmental Health. 20: pp. 367-377.

Grue, C.E.; Christian, C.L.,1981. Use of Captive Starlings to Determine Effects of Pollutants on Passerine Reproduction. Avian and Mammalian Toxicology; Second Conference; Louisville, Kentucky: pp. 5-18.

Hall, Frederick C.,1985. Wildlife Habitats in Managed Rangelands—The Great Basin of Southeastern Oregon. Management Practices and Options. Gen. Tech. Rep. PNW-189. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station.

Halter, M.; Shearer, R., 1980. 2,4-D in the aquatic environment. In: Literature Reviews of Four Selected Herbicides: 2,4-D, Dichlobenil, Diquat, and Endothall; Seattle, Washington; Municipality of Metropolitan Seattle.

Hanley, T.R. Jr., et al. 1984. Teratology and Reproduction Studies with Triclopyr in the Rat and Rabbit. Society of Toxicology; Fundamental and Applied Toxicology. 4: pp. 872-882.

Haque, A.; Ebing, W., 1983. Uptake, Accumulation, and Elimination of HCB and 2,4-D by the Terrestrial Slug, *Deroceras reticulatum* (Muller). Bulletin of Environmental Contaminants and Toxicology. 31(6): pp. 727-733.

Haywood, J.D.,1982. How Site Treatments Affect Pine and Competing Plant Cover. In: Proceedings of the Southern Weed Science Society. January: pp. 224-230.

Heinz, G.H., et al. 1979. Environmental Contaminant Studies by the Patuxent Wildlife Research Center. Avian and Mammalian Wildlife Toxicology; ASTM STP 693; Kenaga, E.E., ed. American Society for Testing and Materials: pp. 9-35.

Hickman, M.V.; Lym, R.G.,1985. Spotted Knapweed: A Threat to the Northern Rangelands. North Dakota State University; Fargo, North Dakota.

Hildebrand, L.D., et al. 1980. Effects of Roundup Herbicide on Populations of Daphina magna in a Forest Pond. Bulletin of Environmental Contamination and Toxicology. 25(3): pp. 353-357.

Hill, E.F.; Camardese, M.B.,1981. Subacute Toxicity Testing with Young Birds: Response in Relation to Age and Intertest Variability of LC50 Estimates. Avian and Mammalian Wildlife Toxicology; Second Conference; Louisville, Kentucky: pp. 41-65.

Hoffman, D.J.; Alberg, P.H.,1984. Evaluation of Potential Embryotoxicity and Teratogenicity of 42 Herbicides, Insecticides, and Petroleum Contaminants to Mallard Eggs. Archives of Environmental Contamination and Toxicology. 13(1): pp. 15-27.

Holechek, Jerry L.,1981. Brush Control Impacts on Rangeland Wildlife. Journal of Soil and Water Conservation. September-October 1981: pp. 265-269.

Ingham, B.,1975. Effect of Asulam in Wildlife Species; Acute Toxicity to Birds and Fish. Bulletin of Environmental Contamination and Toxicology. 13(2): pp. 194-199.

Irvine, A.M., et al. 1976. Effect of 2,4-D on the water soluble carbohydrate content of ragwort (*Senecio jacobaea L.*) leaves. Weed Research. Vol. 17: pp. 169-172.

Kane, M.B.,1982. Effect of Hexazinone Application on Disease and Insect Incidence in Young Loblolly Pine (*Pinus taeda*) Plantations. In: Proceedings of the Southern Weed Science Society. Vol. 35.

Kemp, M.V.; Wightman, J.P.,1981. Interaction of 2,4-D and Dicamba with Chitin and Chitosan. Virginia Journal of Science. 32(2): pp. 34-37.

Kindschy, Robert R., et al. 1982. Wildlife Habitats in Managed Rangelands—The Great Basin of Southeastern Oregon. Gen. Tech. Rep. PNW-145. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station.

Knowe, S.A., et al. 1982. Third Year Growth Response of Loblolly Pine to Herbaceous Weed Control. In: Southern Weed Science Society Proceedings: p. 159.

Leckenby, D.A., et al. 1982. Wildlife Habitats in Managed Rangelands — The Great Basin of Southeastern Oregon—Mule Deer. Gen. Tech. Rep. PNWl-139. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station.

Lichtenstein, E.P., et al. 1973. Synergism of Insecticides by Herbicides. Science. 181(4102): pp. 847-849.

Loos, M.A.,1975. Phenoxyalkanoic Acids. In: Herbicides: Chemistry, Degradation and Mode of Action; Kearney, P.C.; Kaufman, D.D., eds. Vol.1: Marcel Dekker, New York: pp.1-128.

Loos, M.A., et al. 1979. Phenoxy Herbicide Degradation in Soils: Quantitative Studies of 2,4-D and MCPA-Degrading Microbial Populations. Soil Biology and Biochemistry. 11(4): pp. 377-385.

Mackie, R.J.,1966. A List of Literature on Big Sagebrush Control and Ecological Effects of Sagebrush Control. Montana Fish and Game Department; Helena, Montana.

Mansour, Fedel, et al. 1983. Spider Management in Agroecosystems: Habitat Manipulation. Environmental Management. 7(1): pp. 43-49.

Marsh, Rex E.,1984. IPM Concepts in Vertebrate Pest Control Relative to Forestry In: Integrated Forest Pest Management Symposium; Society of American Foresters; University of Georgia; Athens, Georgia.

Martin, R.P.,1965. Effects of Herbicide Appilcations on Wildlife Populations. Oklahoma Cooperative Wildlife Research Unit; Oklahoma. 42 pgs.

Matida, Y., et al. 1975. Effects of Some Herbicides Applied in the Forests to the Freshwater Fishes and Other Aquatic Organisms. Bulletin of Freshwater Fisheries Research Laboratory 25(1): pp. 41-98.

Mattsson, J.L., et al. 1986. Lack of Neuropathologic Consequences of Repeated Dermal Exposure to 2,4-Dichlorophenoxyacetic Acid in Rats. The Society of Toxicology; Fundamental and Applied Toxicology. 6: pp 175-181.

Mauck, W.L.; Olson, L.E.,1976. Survival and growth of the leopard frog (*Rana pipiens*) as affected by atrazine. Unpublished report. U.S. Fish and Wildlife Service; Fish Pesticide Resource Unit; La Crosse, Wisconsin.

Mayack, D.; Bush, P.B.,1982. Impact of Hexazinone on Invertebrates after Application to Forested Watersheds. Archives of Environmental Contamination and Toxicology. 11(2): pp. 209-217.

McLemore, B.F.,1982. Comparison of Herbicides for Controlling Hardwoods in Pine Stands. In: Proceedings of the Southern Weed Science Society. January: pp. 195-199.

Meehan, W.R., et al. 1974. Toxicity of Various Formulations of 2,4-D to Salmonids in Southeast Alaska. Journal of Fishery Resources Board; Canada 31: pp. 480-485.

Miller, J.,1982. Hardwood Control Using Pelleted Herbicides and Burning. In: Proceedings of the Southern Weed Science Society. January: pp.210-215.

Minogue, P.J., et al. 1982. Development of Hexazinone Formulations for Pine Release. In: Southern Weed Science Society Proceedings. p. 160.

Mola, L., et al. 1987. Effects of Atrazine on Two Species of Collembola (*Onychiuridae*) in Laboratory Tests. Dipartimento di Biologia Animale; Universita di Modena; Modena, Italy.

Neff, D.J.,1974. Responses of Deer and Elk to Beaver Creek Watershed Treatments. Arizona Game and Fish Department; Flagstaff, Arizona: pp. 18-24.

Nelson, L.R.; Haymond, J.L.,1987. Herbicides for Forestry. Forestry Notes; Cooperative Extension Service; Clemson University. No. 20.

Nelson, L.R.; Gjerstad, D.H.,1982. Effective Herbicide Treatments for Herbaceous Weed Control in Young Pine Plantations. In: Southern Weed Science Society Proceedings: pp. 156-158.

Neuman, F.G.; Morey, J.L.,1984. Influence of Natural Enemies on the Sirex Wood Wasp in Herbicide-treated Trap Trees of Radiata Pine in North-Eastern Victoria. Mountain Forest Resource Station; Department of Conservation; Forest and Lands; Sherbrooke, Victoria, Australia.

Newell, K.W., et al. 1984. Phenoxy and Picolinic Acid Herbicides and Small-intestinal Adenocarcinoma in Sheep. Lancet. December: pp. 1301-1305.

Norris, L.; Gratkowski, Graham; Currier, W.F., chairman. [Date Unknown]. Report on Background Information for the Phenoxy Herbicides: 2,4-D; 2,4,5-T; 2,4,5-TP.

Oka, I.N.; Pimentel, D.,1979. Ecological Effects of 2,4-D Herbicide Increased Corn Pest Problems. Contributing Centre for Research; Institute of Agriculture; Bogar, Indonesia.

Olinger, H.L.,1982. How Do You Spell Release? In: Proceedings of the Southern Weed Science Society. January: pp. 216-223.

Ottoboni, M.A.,1984. The Dose Makes the Poison. Vincente Books; Berkeley, California. 222 pgs.

Payne, N.F.; Copes, F., 1986. Wildlife and Fisheries Habitat Improvement Handbook. U.S. Department of Agriculture, Forest Service, Wildlife and Fisheries Administration Report: 340 pgs.

Perry, David A.; Rose, Sharon L.,1983. Soil Biology and Forest Productivity: Opportunities and Constraints. Gen. Tech. Rep. PNW-162. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Range and Experiment Station.

Pimentel, David, 1971. Ecological Effects of Pesticides on Non-Target Species. Executive Office of the President; Office of Science and Technology.

Pimentel, D., et al. 1984. Environmental Risks of Biological Pest Controls. Oikos 42: pp. 283-290.

Popovici, I., et al. 1976. The influence of Atrazine on Soil Fauna. Biological Research Centre; Cluj-Napoca; Romania. Pedobiologia. 17: pp. 209-215.

Prasad, R.,1983. Some Physiological and Phytotoxic Effects of Herbicides on Forest Seeds and Seedlings. In: Proceedings of the Cone and Seed Insects Working Party Conference. Canadian Forestry Service; Sault Ste. Marie, Ontario, Canada.

Ream, Catherine H., compiler. 1981. The Effects of Fire and Other Disturbances on Small Mammals and Their Predators: An Annotated Bibliography. Gen. Tech. Rep. INT-106. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station.

Rodgers, J.G., et al. 1974. Percutaneous Absorption of Several Chemicals, Some Pesticides Included, in the Red-Winged Blackbird. Environmental Physiology and Biochemistry. 4(3): pp. 104-111.

Sanborn, J.R.,1974. The Fate of Select Pesticides in the Aquatic Environment. U.S. Department of Commerce; National Technical Information Service; PB-239-749: 82 pgs.

Savidge, Julie Ann,1978. Wildlife in a Herbicide-Treated Jefferey Pine Plantation in Eastern California. Journal of Forestry.

Schacht, A.J.; Hansen, H.L.,1963. Long-Term Vegetational Changes Following Aerial Applications of 2,4-D and 2,4,5-T in Northern Minnesota. University of Minnesota, School of Forestry. State of Minnesota, Game Research Project W-11-R-24. 100 pgs.

Schmidt, G.H.,1986. Use of Grasshoppers as Test Animals for the Ecotoxicological Evaluation of Chemicals in the Soil. Department of Zoology and Entomology; University of Hannover; German Federal Republic.

Sears, H.S.; Meehan, W.R.,1971. Short-Term Effects of 2,4-D on Aquatic Organisms in the Nakwasins River Watershed, Southeastern Alaska. Pesticides Monitoring Journal. 5(2): pp. 213-217.

Sheehy, D.P.,1978. Characteristics of Shrubland Habitat Associated with Mule Deer Fawns at Birth and During Early Life in Southeastern Oregon. Oregon Department of Fish and Wildlife, Information Report Series, Wildlife Number 78-1. 31 pgs.

Sigmon, C.,1979. Influence of 2,4-D and 2,4,5-T on Life History Characteristics of *Chironomus* (Diptera: Chironomidae). Bulletin of Environmental Contamination and Toxicology. 21(0): pp. 596-599.

Smith, E.H.; Mussehl, T.W.,1964. Pesticides, Wildlife Management, and the Public Forests. In: Proceedings of the Society of American Foresters: pp. 186-192.

Smith, G.E.; Isom, B.G., 1967. Investigation of Effects of Large-scale Applications of 2,4-D on Aquatic Fauna and Water Quality. Pesticide Monitoring Journal. 1: pp. 16-21.

Stephenson, M.; Mackie, G.L.,1981. Effects of 2,4-D Treatment on Growth and Survival of Fingernail Clams (*Bivalvia pisidiidae*) in Artificial Pond Ecosystems. Bulletin of American Malacological Union, Inc.. Vol. 50.

Stoyer, T.L.; Kok, L.T.,1987. Insect-plant Interaction in Integrating *Trichosirocalus horridus* (Coleoptera: *Curculiondae*) and 2,4-D for Cardus Thistle Control. Environmental Entomology. 16(4): pp. 864-868.

Sullivan, T.P.; Sullivan, D.S.,1979. The Effects of Glyphosate Herbicide on Food Preference and Consumption in Black-tailed Deer (*Odocoileus hemionus columbianus*). Canadian Journal of Zoology. 57(7): pp. 1406-1412.

Subagja, J.; Snider, R.J.,1980. The Side Effects of the Herbicides Atrazine and Paraquat Upon *Folsomia candida* and *Tullbergia granulata* (Insecta, Collembola). Pedobiologia. 22(3): pp. 141-152.

Thomas, Jeremy A.,1984. The Conservation of Butterflies in Temperate Countries: Past Efforts and Lessons for the Future. The Biology of Butterflies. Academic Press; London.

U. S. Environmental Protection Agency. June 1986. Ecological Risk Assessment. Hazard Evaluation Division; Standard Evaluation Procedure.

Vardia, H.K.; Rao, P.S.,1983. Sensitivity of Toad Larvae to 2,4-D and Endosulfan Pesticides. Archiv fur Hydrobiologie. 100(3): pp. 395-400.

Westra, P.H., et al. 1981. Weevil (Notaris bimaculatus) Feeding Reduces Effectiveness of Glyphosate on Quack Grass (*Agropyron repens*). Weed Science. 29(5): pp. 540-547.

Wilbert, D.E.,1963. Some Effects of Chemical Sagebrush Control on Elk Distribution. Wyoming Game and Fish Department; Project No. W-067-R; Cheyenne, Wyoming.

Wisconsin Department of Natural Resources. 1981. Leopard Frog Populations and Mortality in Wisconsin. Tech. Bull. No. 122. Department of Natural Resources; Madison, Wisconsin.

Woodward, D.F.,1976. Toxicity of the Herbicides Dinoseb and Picloram to Cutthroat (*Salmo clarki*) and Lake Trout (*Salvelinus namaycush*). Journal of Fishery Resources Board, Canada. 33: pp. 1671-1676.

Yokoyama. V.Y.; Pritchard, J.,1984. Effects of Pesticides on Mortality, Fecundity, and Egg Viability of *Geocoris pallens* (Hemiptera: *Lygaeidae*). Journal of Economic Entomology. 77(4): pp. 876-879.

Young, A.L., et al. 1975. Studies of the Ecological Impact of Repetitive Aerial Applications of Herbicides on the Ecosystem of Test Area C-52A, Elgin Air Force Base, Florida. US Department of Commerce; National Technical Information Service; AD-A032-773: 126 pgs.

Appendix K

Methodology Used to Project Particulate Emissions from Prescribed Burning

K

Appendix K

Particulate Emissions from Prescribed Burning

Table of Contents

K Particulate Emissions

Introduction

This method is based on the modeling approach developed by Sandberg et al. (1985) for inventorying particulate emissions from slash burning in western Oregon and Washington. Developed for Region X (Seattle) of the Environmental Protection Agency, particulate emissions were projected in a process consisting of:

1) describing the prescribed burning program anticipated on each National Forest under each of the eight vegetation management alternatives; and

2) estimating biomass consumption and pollutant emissions for each alternative.

In each step, the projections were made by summing up specific projections for small areas of specific forest types, harvest method, and fuel treatment option.

The model accounts for the effects of daily and seasonal variations in fuel moisture content, fuel characteristics, and weather conditions on particulate emission factors and on the amounts of woody fuels and litter/duff consumed.

Sandberg extended his model to accommodate range and wildlife habitat prescribed burning and broadcast underburning practices, techniques included in the EIS Thermal Method of managing vegetation.

Sandberg (1986) and Sandberg et al. (1985) reported on the particulate emission inventories completed for western Washington and Oregon for a base period of 1976-79 and 1984. The state smoke management data bases contained location, date and time, type (broadcast or piled), area, and firing method for each burn—data essential for developing the emissions information for the two base-periods. Emission inventories for Eastside National Forests could not be developed except for one Oregon National Forest, the Deschutes. Prescribed burning east of the Cascades was not regulated under the smoke management programs of the two states.

Annual emissions of particulates less that 2.5 microns in diameter (PM2.5) were calculated for each National Forest for 1986 and for the year 2000 for each of the seven vegetation management alternatives (19+(19X7)= 152 analysis). The results, for the 1983-85 base period and for each alternative for the year 2000 were aggregated for four subregions: eastern Oregon, eastern Washington, western Oregon, and western Washington. The results are presented in Chapter IV.

The relationships among the various steps of the method are illustrated in Figure K-1. Each step will be discussed in a subsection that follows.

Data Collection

To provide a common reference for comparing the eight vegetation management alternatives, the National Forests provided data about their prescribed burning programs and practices typical of the years 1983, 1985, and 1986. They were then asked for their best estimates of those same descriptors for the prescribed burning program that would be implemented under each of the seven vegetation management alternatives presented in the DEIS for the year 2000. The year 2000 was chosen because that is the target year in Oregon for achieving a 50 percent reduction of emissions from prescribed burning. (That reduction is from a 1976-79 base period; not from the 1983-85 base period.) The specifics of the survey data follow:

Situation:

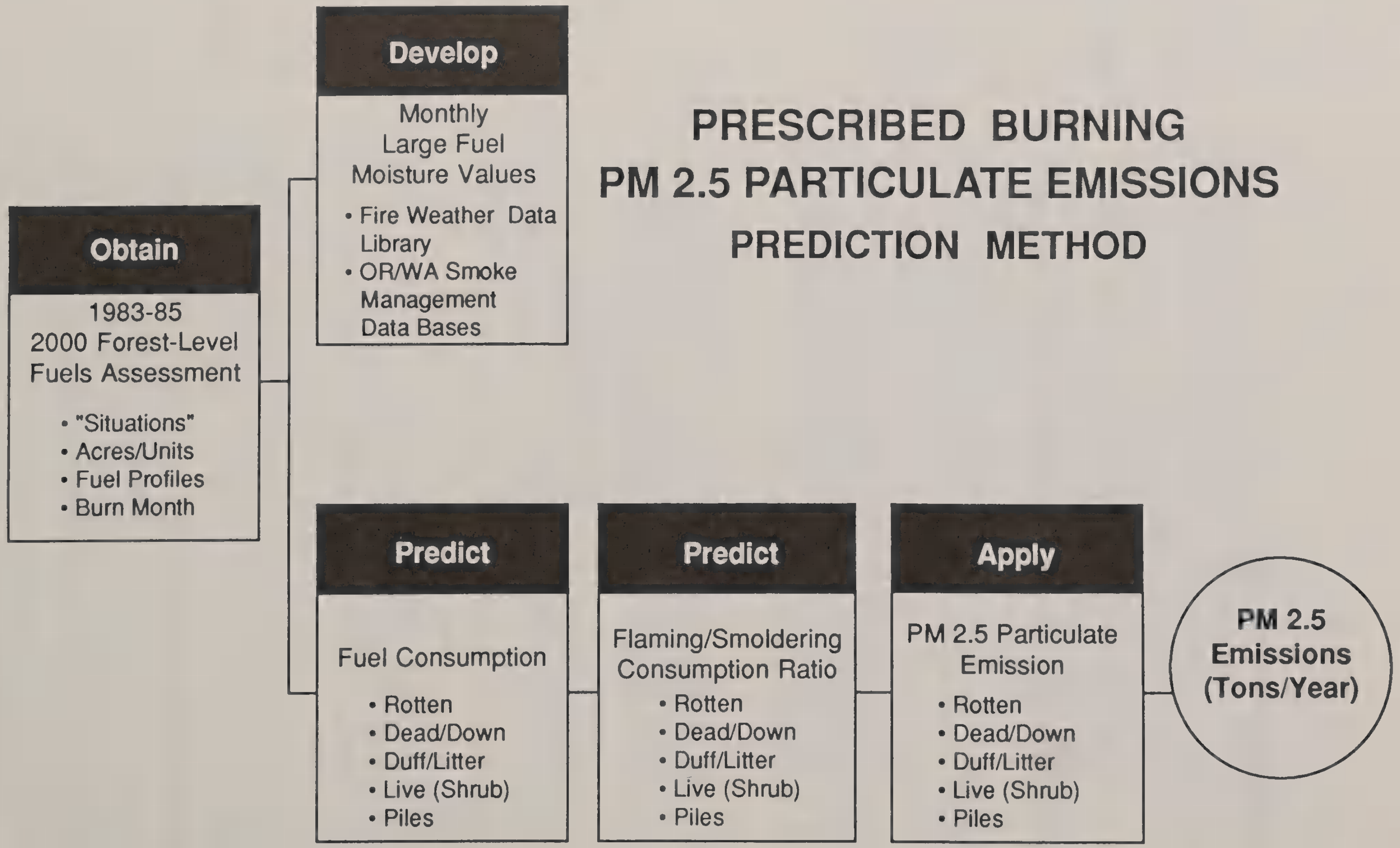
An "activity" fuel situation consists of species, stand history, cutting prescription, burning method, and preburning fuel removal (YUM). The choices presented to the Forest fire management specialists were:

- **Vegetative type:** Ponderosa pine, other conifer, lodgepole pine, hardwood, or hardwood and other conifer.
- **Cutting prescription:** clearcut, partial cut, or whole tree harvesting.
- **Stand history:** old-growth or second growth.
- **Yarding practice:** YUM (unmerchantable material is yarded) or not YUM.
- **Disposal method:** broadcast burned, piled, or piled and broadcast burned.

A fuel situation example is a clearcut, second growth Douglas-fir/ western hemlock (other conifer) stand that will be YUMed; the unit will be broadcast burned. Another is a partial cut, old-growth ponderosa pine stand that will be whole-tree yarded; the slash will be machine piled and burned.

A "natural"situation was included for "non-activity" fuel.s

PRESCRIBED BURNING PM 2.5 PARTICULATE EMISSIONS PREDICTION METHOD



The number of fuel situations identified by the Forests varied from three to 28. The expected shift from old growth to second growth was reflected in these data.

Acres, Number of Units, and Ignition Method:

The Forest specialists were asked for the number of units and acres they expect to burn annually in each of the fuel situations and the percentage of the units that will be mass ignited (such as using a torch suspended from a helicopter).

Though not used in this analysis, mass-ignited units are thought to produce less than one-half the particulates of a comparable hand-ignited unit; the fuel consumption is halved and more of the fuel is burned during the flaming combustion stage.

A significant shift away from hand ignition was projected by all Forests by the year 2000.

Fuel Profile:

A measure of the amount of the different classes of fuel were required for each fuel situation. The litter/duff values are reported as percent of the area of each fuel situation with litter/duff depths in the three classes.

Dead/Down Woody Fuel (tons/acre)	**Litter/Duff** (percent area)	**Live Fuel** (class)
0 to 1 inch diameter	0 to 1 inch	Light
1 to 3 inches diameter	1 to 2 inches	Moderate
3 to 9 inches diameter	>2 inches	Heavy
> 9 inches diameter		

This information showed that the variation of fuel quantities between and within Forests was very high and that better utilization is expected to reduce the quantities of the larger fuels by the year 2000.

Month of Burn:

The percentage of the units burned, by month, from June through October and for the remainder of the year was required for estimating the moisture contents of the fuel larger than three inches in diameter. The amount of woody and forest floor fuel consumed and how much smoldering takes place are a function of large fuel moisture content.

The data showed that the trend between the 1983-85 period and the year 2000 is for a shift away from summer and fall burning toward spring burning. Higher fuel moistures characteristic of the earlier months limit fuel consumption, thereby reducing particulate emissions.

Fuel Moisture Estimates

The 1984 fuel moisture data for western Washington and Oregon were available in the smoke management data bases; estimates for 1983-85 and for the year 2000 for all four subregions had to be developed. Key fire weather stations were identified in each subregion, and the daily weather observations for 1981-84 (precipitation duration, 24-hour maximum and minimum temperatures, and 24-hour maximum and minimum relative humidities) were obtained from the National Fire Weather Data Library (Furman and Brink 1975).

Those data were processed using the large fuel moisture model developed for the Douglas-fir region by Ottmar and Sandberg (1983). The averages of the five years of daily values were used in the consumption models described in the following section. They are:

Adjusted 1000-Hour Timelag Fuel Moistures (Percent)

Month	Eastern Washington	Western Washington	Eastern Oregon	Western Oregon
June	34	40	28	40
July	31	37	24	37
August	24	29	21	30
September	22	31	21	30
October	27	30	22	32
Nov.-May	39	41	36	42

These values were weighted by the prescribed burning activity (acres) for these time periods. The weighted adjusted 1000-hour timelag values were used in the consumption equations.

Fuel Consumption Estimates

Dead and Down Woody Fuels:
This model was developed by Sandberg and Ottmar (1983) to predict the consumption (diameter reduction and tons/acre) for broadcast prescribed burning in the Douglas-fir region. More recent (unpublished) data has shown that the model works acceptably well in hardwood and pine woody fuels (Ottmar 1986). The adjusted 1000-hour timelag fuel moisture is the single independent variable in the model that predicts inches of diameter reduction; the diameter reduction is independent of the original piece diameter.

The consumption (tons/acre) of any class of fuels can be calculated if the quadratic mean diameter of the fuel class is known. The quadratic mean fuel diameters used in this analysis were 5.13 inches for the 3- to 9-inch class and 12.44 inches for fuels larger than 9 inches

in diameter. All of the 0- to 1-inch class and 90 percent of the 1- to 3-inch class are consumed.

Machine Piles:
Fuel consumption for pile burning has not been modeled. For this analysis the assumption was made that 98 percent of 0- to 3-inch diameter fuels, 95 percent of the 3- to 9-inch diameter fuels, and 90 percent of the greater-than-9 inch diameter fuels were consumed.

Forest Floor (Litter and Duff):
Burning litter and duff are responsible for up to half of the particulates produced by a wildland fire (Sandberg and Ottmar 1983). Ottmar (1986) provided information on duff consumption for hardwoods, hardwoods and conifers, and pines. For duff moisture contents above 30 percent in hardwood and short-needled conifer stands, the amount of forest floor consumption is dictated by the large fuel consumption (previous section); duff will burn independently of any dead and down woody material at moisture contents below 30 percent. The model was constrained when applied to areas with thin litter and duff layers. Hence, the requirement for the Forests to provide information on forest floor depths.

The amount of forest floor consumption in underburned pine forests is thought to be controlled by the moisture content of the duff layer. Unpublished data from current research was used to develop a model of duff consumption based on preburn duff loading and the average number of days since rainfall.

Duff consumption in piled units was assumed to equal 10 percent of the preburn duff loading.

Rotten Woody Material:
Information on either the quantities of rotten material or its consumption are not known with any degree of confidence. For this analysis, the rotten woody fuel component loading was set at five tons/acre for Westside units and 3.5 tons/acre for Eastside units; the diameter reduction was estimated to be 1.5 times that predicted for the sound woody fuel component.

Natural Fuels:
A constant of five tons/acre consumed was assigned to all natural fuel acres, East-side and Westside.

Emissions Prediction

Combustion stages:

There are several recognizable stages of combustion, but only two are of concern here: flaming and smoldering. Because combustion efficiency is much better during the flaming stage than during the smoldering stage, the particulate emission factor (pounds of particulate/ton of fuel consumed) is lower for the flaming than for the smoldering stage. The emission factors used in this analysis were supplied by Ward and Hardy (1986).

Fuel Type	Combustion Stage	PM2.5* (lb./ton)
Pine	Flaming	11.88
	Smoldering	32.06
Other Conifer	Flaming	14.90
	Smoldering	26.00
Hardwood	Flaming	14.60
	Smoldering	31.86
Hardwood/ Conifer	Flaming	14.60
	Smoldering	31.86
Piles	Flaming	9.28
	Smoldering	13.06
Natural	All	40

*Particulate matter less than 2.5 microns in diameter.

Partitioning Flaming and Smoldering Consumption:

The true emission factor for a prescribed fire depends on the proportion of total consumption that occurs during the flaming and smoldering stages. Ottmar (1984) developed a model that predicts the proportion of consumption occurring during the flaming stage. The prediction is a function of:

1) the loading of the 1-to 3-inch size class,

2) the consumption of that same fuel class, and

3) the type of burn (broadcast or piles).

Typically, 80 percent of the consumption of piled slash occurs during the flaming stage. In broadcast burns, 20 to 80 percent of the consumption may occur during the flaming stage.

Compilation of Results

For the 1983-85 base period and the year 2000, the tons/year emissions predictions were summed over all:

1) activity and natural fuel classes in each fuel situation,
2) fuel situations in each vegetation management alternative, and
3) Forests in each of the four subregions for each vegetation management alternative.

The results are presented in Chapter IV.

The projections for the year 2000 for each alternative were then compared to the 1983-85 values to generate the comparisons presented in Chapters I and II.

The PM2.5 particulate emissions were calculated instead of the PM10 or total suspended particulates (TSP) because PM2.5 standards will likely be promulgated before 1990. These revised standards will address both inhalable and respirable particulates. Inhalable particulates generally are deposited in the upper portion of the human respiratory system, and may be expelled. Respirable particulates are likely to be deposited in the pulmonary tract and retained in a person's system for a relatively long time. Inhalable particulates are less than 10 microns in diameter (PM-10); respirable particulates are less than 2.5 microns in diameter (PM-2.5).

The PM2.5 particulates are the critical particulate fraction when projecting prescribed burning smoke impacts on visibility and human health. To convert the PM2.5 values to "approximate" PM10 values, multiply the PM2.5 values by 1.13; to convert PM2.5 to "approximate" total suspended particulate (TSP) values, multiply by 1.25.

Alternative H

The projected emissions for Alternative H were developed from the fuel situations submitted by each Forest for Alternative B. The acres/units for each "B" activity fuel situation were not changed, since the burning programs for Alternative B had already been constrained by the fire specialists to meet the Washington 1990 and the Oregon 2000 particulate emissions reduction targets. The spirit demonstrated by fire use planners in developing the Forest-level Alternative B prescribed burning programs is in concert with the Alternative H theme to reduce reliance on prescribed fire for managing activity-generated forest residues (slash).

The emission projections for Alternative H are presented with the projections for the other alternatives in Chapters I, II, and IV.

U.S. GOVERNMENT PRINTING OFFICE: 1988—691-059/80,704 REGION NO. 10